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Cash & Carry Sector: Location Models and GIS Decision Support

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DECLARATION

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Abstract

Although diverse methods / models have been studied and applied in general retail location areas, very few actually related to an important trade sector - Cash & Carry / Warehouse Club. Because of the distinguishing characteristics of this sector, the methods and models successfully used in other sectors cannot be simply transferred.

To solve this problem, a thorough study has been conducted to compare the characteristics of the sector with available methods / models. Based on the outcome of this study, the regression model has been identified to be a better choice for the sector.

Multiple key regression issues, such as model selection, trade area definition, overfitting and multicollinearity, measurement of competitiveness, subjective judgements and quantitative modelling, etc., have been explored in the configuration of a regression model for the sector. The resulting model based on the data from a British Cash & Carry company has achieved the highest R^2 and R^2 (adj) when compared to similar research (based on literature search up to the year 2003).

With the emergence of Geographic Information System (GIS), a powerful spatial information analysis tool, retail location enters the era of the use of Spatial Decision Support System technology to enhance the decision efficiency. Meanwhile, a dynamic location analysis system is important and necessary to retailers. This is why a Spatial-DSS is proposed and designed in the thesis.

The designed system integrates technologies such as Database Management Systems (DBMS), Statistics Software, Geographic Information Systems (GIS), Global Positioning System (GPS), Analytic Hierarchy Process (AHP), Decision Support Systems (DSS) and others. Although these technologies have been used in various areas before, integrating them to form a coherent unity is new.

Chapter 1 The Problem and Its Setting

1.1 The Importance of the Location Decision in Retailing

To locate a single or a chain of store sites is perhaps the first and most important issue that retail decision-makers must face. This kind of decision is related to long term and vast volume investments. Also, (maybe more of a concern to retailers) a practical location plays the most vital role in a retail store's success.

When a location decision is made, a series of spatially related factors must be considered and assessed:

- Who are the key consumers or customers? Where do they live? What status (age, income, education, etc.) do they hold? What kind of shopping behaviour do they have (multiple purposes or single purpose, car-based or public transportation-based)?
- How is the competition distributed in the area? How many competitors exist around? Are they stronger or weaker than the object store? Where are they located?
- Where are the suppliers (or the distribution centre for a multiple retailer)? How long do the deliveries take? How much does the transportation cost?

A carefully selected store site can attract more customers, avoid unnecessary losses from the competition and save delivery costs and inventory costs. On the other hand, any failure on considering the above spatial issues will incur losses. It is not uncommon to see that stores are forced to close because of inappropriate locations.

Because of its importance, retail location theory study and modelling development have remained one of the 'hot topics' in the retailing area. Since Walter Christaller published his Central Place theory in 1935, which can be counted as the beginning of retail

location study (Craig 1993), retail location theory and modelling has gone through a path of Central Place Theory (Christaller 1933), Analogue Approach (Applebaum, 1960) and Gravity Model (Huff, 1962) to modern quantitative models such as MULTILOC (Achabal 1982), ILACS (Goodchild 1984) and STORELOC (Duravasula, 1992).

The newly invented computer technology, Geographic Information Systems (GIS), has injected the retail location analyses with a strong stimulus. Many GIS vendors, such as ESRI and Mapinfo have integrated the location models (mainly based on the Gravity model, or Huff's model) into their software for retail users. More and more retail location analysts and researchers have already accepted GIS as a very useful tool for their location analyses.

Despite the blossoming of retail location development, a special trade sector - Cash and Carry in the United Kingdom, or Warehouse Club in North America - certainly has been ignored by the researchers and analysts and is left as an undeveloped area. The updated literature search conducted by the author found very few studies applied to this sector.

1.2 Cash and Carry / Warehouse Club: An Important and Under-considered Sector

The Cash and Carry / Warehouse Club is a form of trade in which goods are sold from a wholesale warehouse operated either on a self-service basis, or on the basis of samples (with the customer selecting from specimen articles using a manual or computerized ordering system but not serving him/herself), or a combination of both. Customers (retailers, professional users, caterers, tradesmen, institutional buyers, etc.) settle the invoice on the spot and in cash, and carry the goods away themselves (Eurostat 1993).

The emergence of this form of business was due to the 'traditional' two sectors, retail and wholesale, not fully meeting the requirements of customers such as independent retailers or caterers. For these customers, the products from normal retailers, whose targets are the end consumers, are too highly priced. On the other hand, delivered wholesalers require a larger ordering quantity and longer lead time, which is of concern to the small retailer or caterer.

Because of the above problem, Cash and Carry / Warehouse Club trade was developed to fill the gap. The customers not only receive the benefits of low prices (compared with retail prices) and instant supply, but also the ability to choose the products on a 'touch and feel' basis, just as the consumers buying goods from a retail store. This feature attracts many small or home-based businesses.

Generally, there are two types of Cash and Carry / Warehouse Club. The first is run just like a storage warehouse, or warehouse with aisles. It is normally not open to the public. Customers come to order and pick up the goods. For this kind of Cash and Carry / Warehouse Club, store image is not very important.

The second type, more popular now, is open to both businesses and selected individuals. For this type of Cash and Carry / Warehouse Club, store image is important. It represents a combination of pure warehouse and retail store form.

From the location analysis point of view, both types of Cash and Carry / Warehouse Club have the following characteristics:

- Most direct customers are small retailers and caterers, instead of the final consumers (See Table 6.3.1 for the customer split).
- Although not in bundles, the quantities are still big, which means the customers must have their own transportation facilities.
- The assortment of merchandise is limited (compared with supermarkets).
- The stores normally occupy larger spaces. Part of the reason is that the aisles are wide so forklifts can pick up pallets of merchandise and arrange them on the selling floor.
- They are mainly concentrated in the grocery sector.

Cash and Carry occupies an important role in current retail trade industry. In the UK, it accounts for 60~63% of the grocery wholesaling industry, with a total yearly turnover of £9 billion pounds (Key Note, 2000, 2001). Following are figures in recent years:

Table 1.1 Cash and Carry in UK

Year	Turnover	Grocery Wholesaling Share
1992	£8.65 bn	
1996	£9.51 bn	
1997	£8.80 bn	
1999	£9.5 bn	63%
2000	£9.2 bn	60%

Source: Key Note (1997, 2000, 2001)

Table 1.2 provides the comparison of different types of food retailers in America:

Table 1.2 Types of Food Retailers in America

	Conventional Supermarket	Superstore Combination	Supercenter	Warehouse Club	Convenience Store
Sales (\$billions)	143	158	45	22	28
Number of Stores	18,200	9,200	3,300	750	57,000
Sales/Stores (\$m)	7.9	17.2	13.6	29.3	0.5
Size (000 sq.ft)	20	20~50	100~150	100~150	2~3
SKUs(000)*	20	30	30	20	2~3
Variety	Average	Broad	Broad	Broad	Narrow
Assortment	Average	Average	Average	Low	Average
Services	Average	Average	Average	Low	Average
Checkout lines	6~10	10~20	20~30	10~15	1~2
Prices	Average	Low	Low	Low	High

*Supermarket items only.

Source: 66th Annual Report of the Grocery Industry, Supplement to Progressive Grocery, April 1999

The above table reveals that, although the total of warehouse club sales is not the highest, the sales per store and store size are the highest among all food retailers.

Cash and Carry in the UK is facing intense competition in the market place. Key Note Ltd. pointed out, by comparing the data of year 1999 and 2000, that the Cash and Carry sector “will face a stronger threat from the growing dominance of the major grocery multiples and the increased competition from the delivered trade”. From 1999 to 2000, Cash and Carry’s market share declined from 63% to 60%. It “will decline by around 2.3% between 2001 and 2005”.

In order to overcome these problems, many leading Cash and Carry / Warehouse Club operators have adopted a series of strategies. Among them, location strategy has won more attention than before (Davies 1994). A strategically selected location not only can effectively cut down the operators’ costs, but also greatly increase the performance.

Traditionally a Cash and Carry / Warehouse Club is normally located in a business area, close to the suppliers and has the lowest land cost. The location choice does not consider the convenience to the customers, or the distance to its clients. The reason is that this trade sector used to be seen as a semi-wholesaler, from which the customers can get products with cheaper prices. For this reason, customers did not care about the distance or the convenience. But since the multiple outlet groceries changed their price policies, this advantage is not so obvious. Just as McMgee (1994) said: “Cash and Carry are no longer low price operators. The multiples and discounters have taken that competitive weapon away from us”.

1.3 Objectives of the thesis

Based on the above analysis, it is clear that Cash and Carry / Warehouse Club is an important trade sector and currently it is under intense pressure from competition. This leads to the appeal of possible strategic reform. Location modelling is potentially one of the effective ways to introduce development.

However, current retail location analyses are all based either on general retailers, or the retailers taking end consumers as the customers. Cash and Carry / Warehouse Club, as a special trade sector, has its own distinguishing characteristics. Special customer groups and bundled products are the two most important ones. How to build up a location model for this type of ‘store’ is an unsolved problem.

This thesis aims to fill that gap. It first provides a thorough review of the current available retail location models / methods with the analyses of their application areas, advantages and limitations. Next, the study focuses on the particular location issues related to Cash and Carry / Warehouse Club characteristics. The key issues discussed are trade area calibration and location method selection. The model and methods identified by the discussion will then be applied to a real application: calibrate a location model for a Cash and Carry chain in the UK. Finally, a GIS aided spatial decision support system is proposed. The goal of this system is to automatically select the best location by applying the theories and methods resulting from this research.

The objectives of the thesis are to:

1. Provide a thorough review of the current available retail location models / methods with the analyses of their application areas, advantages and limitations;
2. Systematically investigate and analyse the relations between spatial factors and store performance;
3. Discuss some unsolved and arguable issues such as trade area delimitation, model selection (gravity against regression), and the balance between subjective judgements and quantitative modelling;
4. Develop a location model that is best fitted to Cash and Carry / Warehouse Club characteristics and apply it to a real location application for a Cash and Carry chain in the UK;
5. Explore the benefits and methods of using GIS to support retail location planning;
6. Based on the above study results, design a GIS aided Spatial-DSS. The system should have the abilities to auto-configure the optimum location model based on the provided data.

The data used for this study is mainly based on a project, conducted between 1994 and 1996, for a British Cash & Carry chain retailer. However, the literature review and design concepts have been updated to reflect the current development trend.

Chapter 2 Retail Location Literature Review

2.1 Retail Location Theory

Location analysis can be traced back to ancient times in China, where people started the semi-mystical approach “Feng Shui” to site selection. (Thrall, 1996).

“Feng Shui” applies many judgement factors to the site. Some of them are spatially related, such as the environment (e.g. the selection of a site located in beautiful scenery) and road structure (T-junction vs. roundabout). Some others are very subjective or even superstitious (e.g. year or date when the head of a family was born).

“Feng Shui” ideas are still used by some Chinese people when they try to select a site, either for business or residence.

The well accepted beginning of ‘scientific retail location’ history is actually in 1933 when Walter Christaller published his paper “*Die zentralen Orte in Süddeutschland*”, which later on was recognized as the Central Place Theory. This publication, according to Stephen Brown (1993), is a momentous event in retail location study. Central Place Theory was later further developed by A. Losch (1940).

The heart of Christaller’s theory was founded on the two concepts: range and threshold. The range was considered to be the maximum distance that consumers be willing to travel to an outlet (the outer circle in following figure). Threshold was defined as the minimum amount of consumer demand in an area on which a store could exist profitably (the inner circle). The range and threshold were also called outer range and inner range respectively. According to Christaller’s conclusion, the condition for a shop to run economically was that the outer range must exceed the inner range.

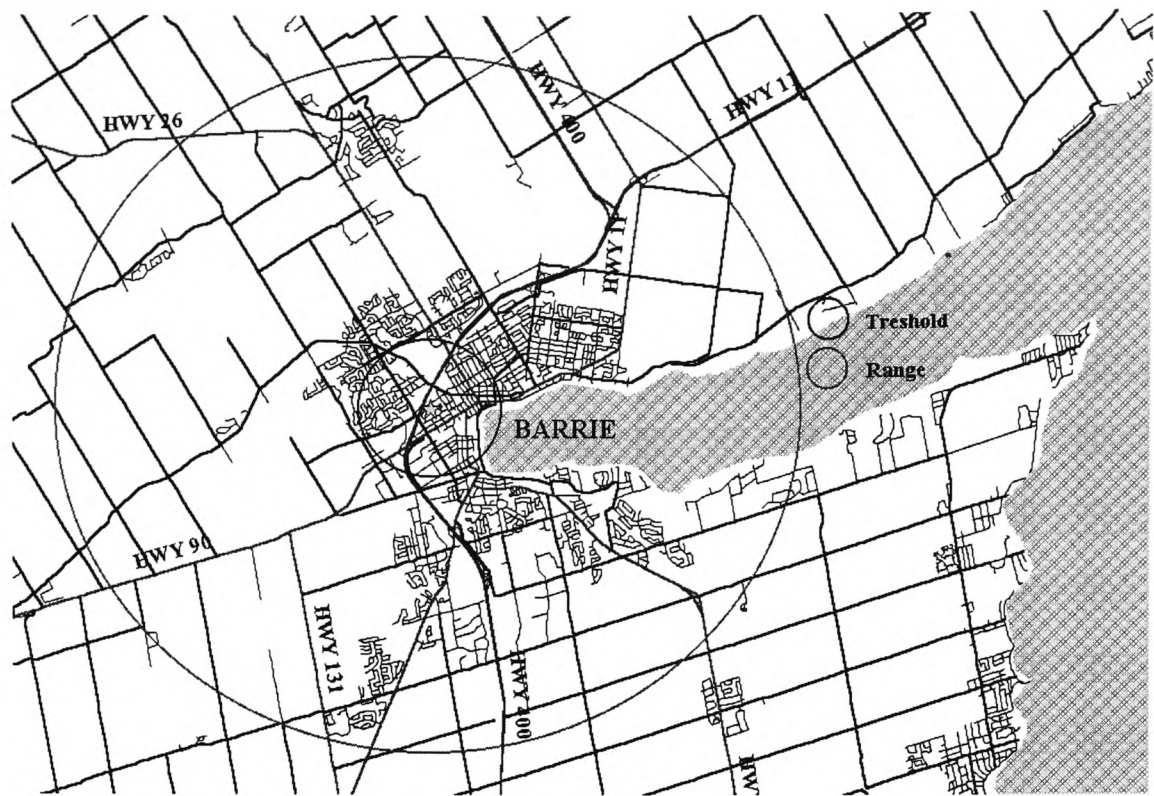


Figure 2.1.1 Range and Threshold of a Store in Barrie, Ontario, Canada

Losch gave another approach to the theory. He considered that because transport cost increased with distance, the real price of a good would increase and this led to a decrease in demand. This kind of decrease with distance would form a spatial demand cone. Losch proved that a store could perform economically only if its total demand, represented by the spatial cone, was above some certain level.

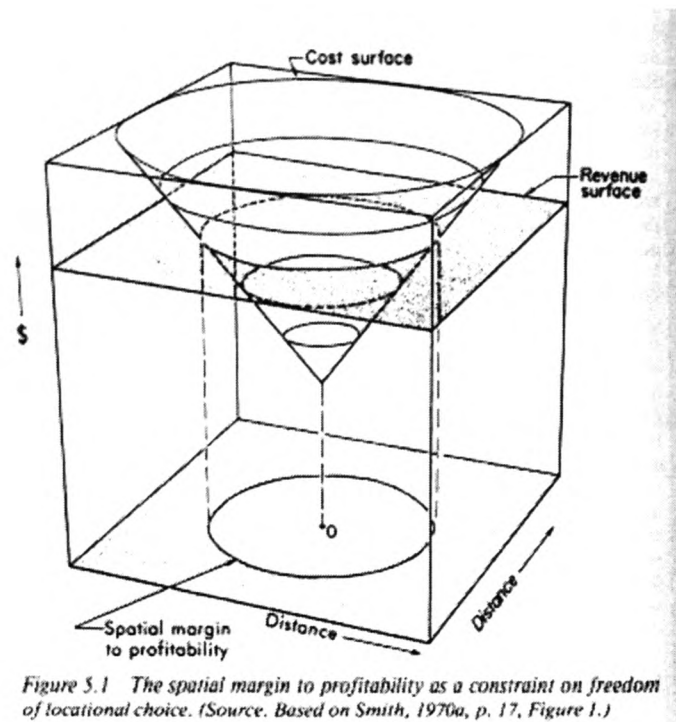


Figure 2.1.2 Losch's Demand Cone

Central Place Theory has been considered as the “best developed normative theory of retail location. ... The value of Central Place Theory lies in its abilities to consider simultaneously the behaviour of consumers and retail firms in a spatial market” (Craig and Ghosh, 1984).

One of the great contributions of Central Place Theory is that it successfully revealed the importance of two spatial factors, in terms of consumer demands and travel distance, to retail performance. Macro market structure can be well explained by its “range” and “threshold” concepts:

- Normally, the expensive and infrequently sold merchandise items have a higher threshold, but can expect a higher range because consumers do not mind travelling long distances for this kind of shopping.

- There are a larger number of “lower order” (lower threshold and range, such as groceries) stores and smaller number of “higher order” (higher threshold and range, such as furniture shops) in the market.
- Range is highly correlated to the density of population. That is the reason why more stores are located in urban cities than in the rural areas.
- Since “Market areas expand the size in low-density areas and shrink in high density areas to accommodate threshold population” (Craig and Ghosh, 1984), the most specialised goods and services are usually located only in shopping centres.

Another theory that has dominated retail location field is the Spatial Interaction Theory (Reilly, 1931). Reilly explained the retail market through another direction: taking consumer spatial behaviour into account. He stated: “two cities draw trade from an intermediate city or town ... approximately in direct proportion to the populations of the two cities and in inverse proportion to the square of the distances of these two cities to the intermediate town”.

This theory was named as “Law of Retail Gravitation” because, as explained by Reilly, consumers were attracted by the store just as physical objects are attracted under the Gravitation Law of Newton: the more attractive the store is, the more consumers it has.

Reilly’s law explained well a market phenomenon whereby consumers often trade off the travel cost against the attractiveness of stores and do not follow the “nearest centre hypothesis” asserted by Central Place Theory.

Beyond the consumer demands and travel distance, Reilly introduced the third spatial factor, trade area population, into retail location research.

The third theory that contributed to location study was the Bid Rent Theory, developed by Robert Murray (1926, 1927). Bid Rent Theory introduced another spatial element, the site rent, into location analyses. By recognizing the relation between a location and

the land value or urban rent, it hypothetically assumed that in an environment with a landscape comprising a uniform plane where travel is equally easy in all directions, the centre of the plane is the most acceptable and thus lowest cost location. This kind of location would be bid by various land uses. So this kind of location could be ranked into an order of rent-paying precedence. The result of competition would ensure that, in the long run, all centre locations, or urban sites, are occupied by the activities capable of paying highest rents. Thereby, land is put to its 'highest and best' use.

Subsequently, various researchers tried to use other spatial variables to study retail performance. Brunner and Mason (1968) revealed the influence of travel time, instead of the physical distance, over consumers' shopping preference. Cadwallader (1981) introduced consumer cognition, a subjective factor, into retail location.

2.2 Retail Location Models

The early retail location analyses were based on Checklist and 'Analogue' methods that used spatial factors subjectively. The factors were ranked by the analysts in order to compare among the multiple candidate sites.

Checklists, according to Applebaum (1965), were the earliest method used to evaluate systematically feasible sites and seek the optimal locations. They involve the identification of location factors, such as socio-economic and demographic composition, levels of competition, consumer expenditure patterns, as well as traffic, parking, visibility of the sites, etc.

'Analogue' is a more sophisticated approach (compared to the Checklist method) to site selection. This method tries to assess the potential sites by comparing them with the existing sites that have a similar spatial pattern.

In the development of retail location research, quantitative methods were eventually introduced. One of the popularly used quantitative models in retail location is the Gravity model (Huff, 1962, 1963). The model is based on the central place theory and spatial interaction theory. Therefore it is also known as the 'gravity', 'spatial

interaction' or 'spatial choice' model (Craig 1984). Because of the great contribution of Huff, this model often is known as Huff's model.

The model can be expressed as:

$$U_{ij} = A_j^\alpha D_{ij}^{-\beta} \quad (2.2.1)$$

$$P_{ij} = U_{ij} / \sum_{k=1}^n U_{ik} \quad (2.2.2)$$

Where: A_j is the attractiveness of Store j ;

D_{ij} is the distance of area Zone i to Store j ;

U_{ij} is called (by Huff) the utility of Store j to consumers in Zone i ;

$\sum_{k=1}^n U_{ik}$ is the sum of the utilities of all stores, including Store j and its competitors;

α, β are the elastic parameters;

$$\alpha \geq 0, \beta \geq 0$$

P_{ij} represents the probability of consumers in Zone i specifically visiting Store j among all the available stores;

n is the number of available stores in the area.

By adding the expenditure potentiality variable E_i (expected amount of consumer spending on merchandise) of Zone i into the above equation, we can determine the sales or turnover of Store j (S_j) using the equation:

$$S_j = \sum_{i=1}^m E_i * P_{ij} \quad (2.2.3)$$

Where: E_i is the expenditure potentiality in Zone i

m is the number of zones in the trade area.

Huff's model played an important role in retail performance assessment, but it was also criticized for its use of single dimension of store attractiveness (size or sales) and spatial factor (distance).

To solve this problem, Nakanishi and Cooper (1974) proposed the Multiplicative Competitive Interaction model, known as MCI. In the MCI model, multiple store characters and spatial variables can be employed.

Two modifications of MCI were:

- Using $\prod_{t=1}^q A_{ij}^{\alpha_t}$ to replace single attractiveness A_j^α , where A_{ij} is one of q store characteristics, such as floor pace (or sales), accessibility, pricing, etc. α_t is the elasticity parameter.

$$\alpha_t \geq 0$$

- Using $\prod_{e=1}^r D_{eij}^{\beta_e}$ to replace the distance D_{ij}^β , where D_{eij} is one of r factors related to zone i , such as distance, travel time, consumers preference, and so on.

β_e is the elasticity parameter.

$$\beta_e \geq 0$$

While geographers were in favour of using the gravity model to assess the retail location, researchers from other subjects, typically from Management Science, tested the regression method to solve retail location problems (Craig, 1984).

From past research, it was already clear that retail performance was highly related to both the store's internal characteristics and spatial factors. Craig and Ghosh (1984) generalized the relation through the following equation:

$$Y = f \{L, S, M, P, C\} \quad (2.2.4)$$

As described by Craig and Ghosh, the dependent variable (Y) is one of the store's performance measurements. It is related to five independent variable groups:

Location (L), Store attributes (S), Market attributes (M), Price (P) and Competition (C).

There are two types of relations applied in retail research:

Linear relation:

$$Y = a_0 + a_1 * X_1 + a_2 * X_2 + \dots + a_k * X_k \quad (2. 2. 5)$$

Exponential relation:

$$Y = e^{b_0} * X_1^{b_1} * X_2^{b_2} * \dots * X_n^{b_k} \quad (2. 2. 6)$$

One of the best tools to study such kinds of relationships is regression analysis. Actually, because exponential relationships can be easily transformed into linear functions, it is the multiple linear regression that has been widely used in retail location researches.

The advantages of regression are that the model has the ability to filter out the significant factors from many variables. A significant variable means that it has a certain degree of contribution to the goodness of fit, or the explanation level, of the model.

One of the problems in regression analysis was that some researchers took this advantage for granted and put many variables into the first stage of regression analyses. It appeared acceptable at first because all possible factors seemed to be taken into consideration. But blindly dumping factors into models might cause over-fitting problems, that is, the model is wrongly formed, even if it has a high degree of fitness.

Statistically, to avoid the over-fitting problem, the following condition should be kept (Mendenhall and Sincich, 1989):

$$n > 4k$$

Where n is the number observations, k is the number of factors.

Concerning the efficiency of the regression model, Craig *et al* (1984) summarized four common possible failures that need more attention:

- Over-fitting: a failure caused by putting too many independent variables into the model;
- Multicollinearity: a problem arising when there exist near-linear dependencies among the chosen factors in the model;
- Incorrect variable definition and measurements: wrongly defined variables and unsuitable measurements often lead to incorrect regression results;
- Improper geographical areas delimitation: It is obvious that a different size of area delimitation can produce different data. An overly large size will incorporate false data, and, on the other hand, a too small size certainly will lead to some key data being missed (a geographical area is also called ‘sales area’ or ‘trade area’).

The gravity model relies on a field survey to obtain the spatial data. It is time consuming and costly. By contrast, the regression model can utilize secondary data such as yellow pages and the published census data, which can be obtained comparably easier and more reliable.

2.3 Retail Location Applications

Recently, a series of quantitative retail location models have been developed. These models have studied the retail location from different viewpoints.

One of the development trends is the ‘optimization model’, which does not only just seek the maximum output of a single store’s performance, but also tries to cope with other factors and requirements.

Achabal *et al* (1982) developed a model (MULTILOC) to optimize the overall expected profit for a retail chain. MULTILOC was built up on the basis of the MCI model. In order to obtain the optimum value, decision variables x_{jl} were used:

$$\begin{aligned} x_{jl} &= 1 && \text{if a store of design } l \text{ is to be constructed at location } j. \\ x_{jl} &= 0 && \text{Otherwise.} \end{aligned}$$

By introducing the above decision variables, MULTILOC not only can compare among the locations, but also is able to compare different store designs (size, etc.).

Durvasula and Sharma (1992) contributed to retail location study from another direction. They incorporated managerial judgements, together with the conventional consumer data, into their model called STORELOC. They believed that “recent evidence suggests that models incorporating intuition based managerial judgements - tend to be more accurate than those that do not use such judgements”.

In STORELOC it is assumed that when a new retail outlet is opened in a market, its likely market share is a function of:

- a) A proportion of market share captured from each of the existing competitors.
- b) A proportion of market expansion potential captured.

The managerial judgements used in STORELOC are PMIN (minimum proportion of market share captured from any competitor), PMAX (maximum proportion of market share captured from any competitor), S_i (relative strength of competitor i), etc.

The traditional retail location methods such as checklist, analogue and regression models tend to focus on the evaluation of site-specific factors (Craig, 1984). By contrast, another recent development, location-allocation models, not only can simultaneously select the multiple facility locations, but also are able to assign the demands to these locations. The models are claimed to be able to achieve optimum results by combining the location selection and demand assignment ‘under one roof’.

This type of model used to be concentrated in public services. Michael F. Goodchild (1984) tried to introduce the idea into the retail sector and developed a location-allocation model called ILACS. The location-allocation models are especially useful in the multiple outlets situation.

Census data is a very common spatial data source for the quantitative models discussed above. Previously, the data was only available at a certain standard area unit level, e.g., at town or district level. These kinds of units do not usually match the researched trade area, where a trade area can be part of a town or across several towns. Researchers could only choose an area unit that was closest to the potential site. Such a rough approach obviously cannot fully reflect the real spatial structure of the trade area. It explains why the fitness of prior regression models was not very high. Davies (1977) reported $R^2 = 0.76$ for his supermarket study, $R^2 = 0.71$ for a group of clothing stores and $R^2 = 0.74$ for the self-service stores. Morphet (1991) achieved $R^2 = 0.80$ in his grocery store research.

Hence, finding a suitable tool to process spatial data is a crucial task for retail location researchers. It is not only used for improving the quality of the models, but also for the purpose of rapid response and adjustment purposes because the retail environments are changing from time to time. Retail spatial structure is not a built infrastructure that can maintain its original form for a long time. This issue will be discussed in next chapter.

Chapter 3 Spatial Data and Geographic Information Systems (GIS)

3.1 Development and Application of GIS

GIS is a recently developed computer system that unites digital mapping and database management to provide the analysis and synthesis of spatial data. A standard GIS system has common functions such as relational database management, graphic processing, map projecting, etc.

The term “Geographic Information System” was first invented by a geographer in Ottawa, Canada. In the 1960s, Dr. Roger Tomlinson (often referred to the ‘father of GIS’) developed the concept where people could integrate multiple layers of maps and overlay them with information in a computer (Computer World Canada, www.itworldcanada.com, October 5, 2001).

One of the first GIS systems ever used in the world probably is the Canadian Geographic Information System (CGIS) which was used for land inventory (slope, climate, soil, texture, etc.). The concept used in the system was to digitize a map into a computer and then conduct analytic work by overlaying it and producing a new ‘results’ map.

The researches and developments during the ‘70s were concentrated in non-commercial areas. GIS was primarily used by governments and other public service organizations for their non-structural decisions. Typical applications can be found in land planning, emergency reaction, traffic control, and so on. It was the main customer part of GIS application, occupying 40% of the total sales (Kolli, 1993).

It was not until the early ‘80s that commercial GIS software emerged. With increasing interest from business, the marketing oriented GIS software and applications have mushroomed continually. GIS is used as an efficient spatial data accessing and analysing tool by more and more marketing decision makers.

According to the statistics, GIS was growing at a rate of about 60% annually (Michelsen, 1994). It was estimated that “the world-wide sales of GIS, including hardware, software and service, may exceed \$5.5 billion in 1995, which is the double of 1992’s real figures” (Michelsen, 1994). At the end of 20th century, the market capacity of GIS could reach to \$40 to \$90 billion (Kindel, 1993).

In a recent survey conducted in the UK (Hernandez and Bennison, 1998), about 60% of UK retailers adopted GIS technology for locational planning and marketing decision making.

The existing GIS applications can be categorized as:

- **Governments and Public Services**

Land Use Planning: land use conflict analysis; environmental and economic impacts of different development schemes; evaluation of different policies and planning scenarios; site selection of public facilities (school, hospital, emergency station, etc.);

Regional Planning: urban development and control;

Transport and Traffic Management: traffic analysis and control; best route selection; automatic driving guide;

Environment: environment monitoring; resource inventory control; impact assessment; feasibility studies; disaster prediction;

Emergency/Health Care: allocation of the emergency/health care facilities; optimum route planning and reaction policy; damage estimation.

- **Business**

Marketing Research: site selection; competitiveness analysis; target market searching; sales territory planning; promotion, outlet performance assessment;

Network Management: network analysis and demand forecasting for electricity suppliers (and similar suppliers); underground cable/pipe maintenance assistance for cable TV/telephone/gas/water supply businesses;

Distribution: distribution channel planning; fleet management and scheduling; lead time and inventory control;

Bank and Insurance: risk/profit assessment; territory analysis; customer profile, pinpoint and service.

3.2 The Features and Structure of GIS

A GIS is typically made up of a variety of information systems such as Cartographic Display System, Map Digitising System, Database Management System, Geographic Analysis System, Image Processing System, Statistical Analysis System and Decision Support System (Fig.3.2.1). In many ways, learning GIS involves learning to think - think about patterns, about space, and about processes that act in space.

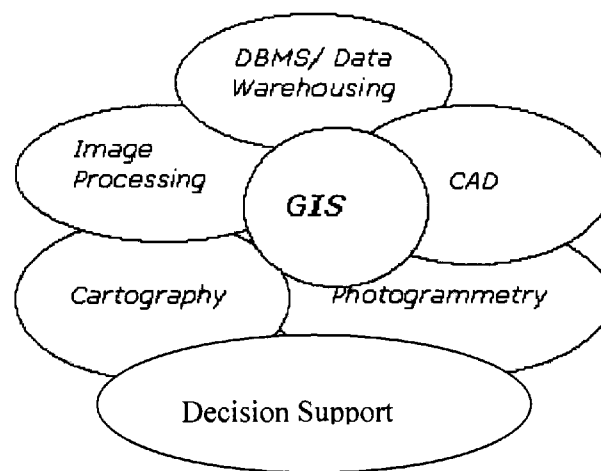


Figure 3.2.1 GIS and Related Disciplines

There are two main features of GIS. First is its ability to manage and integrate spatial data with related geographic elements. The second relies on its analysis and display functionality for spatial images.

The greatest difference that distinguishes GIS from other software dealing with spatial objects (e.g., CAD) is the use of location (or geography) information as an important reference variable in the analysis and modelling. In GIS, every record or digitised object has a unique geographical location that can be displayed on a map. The location is expressed by a pair of co-ordinates, normally called latitude and longitude.

All the information of location is dynamically linked to its geographical position. Users can pinpoint any place to view it. The information not only can be displayed in traditional ways such as, tables or charts, but also can be displayed on a map using different colours, patterns, symbols, icons, etc.

Many authors, such as Hanigan (1988) and Goodchild (1991), tried to define the functions that a GIS should contain. In addition, Crossland *et al* (1995) gave the three most commonly available GIS features, in names as map overlays, thematic mapping and area buffering.

Generally speaking, the following functions are available from the currently marketed GIS packages:

- Geographical Display: geographically display a selected area map with the borders of different parts and natural landmarks, such as rivers, roads, and so on;
- Location Pinpointing: pinpoint the targets and show them on the map by the designated symbols;
- Area Definition: different ways to define a determined area;

- Geodemographic and Geo-business Information Image: use various kinds of shade and colours to show the demographic / business information inherent in the selected area, such as the density of population, levels of income, degrees of competitiveness, etc;
- Distance Related Abilities: compute the distance between the selected targets or search / filter out the objects within / outside a certain distance to the selected location.

Goodchild (1991) gave three basic geographic elements: point, line and area and their relations:

Table 3.1 Relationships Between Three Types of Geographic Objects

	Point	Line	Area
Point	Is nearest to		
Line	Is located on	Crosses	
	Is nearest to	Intersects	
Area	Lies within	Crosses	Overlaps with
	Is outside	Touches	Is adjacent to

In GIS, a point is usually used to represent an entity (e.g., a store), and a line could be a street or a road.

In most marketed GIS, location is normally expressed by the postal code (or ZIP code). In addition to the traditional dual value such as 'YES/NO' or 'Inside/Outside', the relationship between geographical objects can also be represented by the other values, such as 'Distance to' is one of the most useful indicators in retail location.

There are two measurements of distance in GIS. One is the absolute distance, i.e., the physical distance between two objects. It is measured by length unit (e.g., kilometre or mile). Another one is the time distance. It is measured by the time spent getting from one place to another. In Western countries, time distance is usually expressed by the drive time.

Time distance is preferred by retailers because it is the real measure of consumers' spending (time and the cost) on travel. This decides their willingness to shop in a particular store.

To determine drive time, a GIS should have a database which stores the road structure, and another database that keeps the average speed on the roads as well. In the UK, the roads are classified as Motorway, A road, B road and C road. For all the roads except C roads, the AA (Automobile Association) holds detailed statistics of the speeds on each section of a road.

Consumer population composition is one of the important spatial factors for marketing research. For this reason, marketing-oriented GISs often have a built-in demographic database. In this database, the census results are stored by the smallest area unit (usually a postal code or an enumeration area) with several related characteristics (e.g., population, percentage of male and female people, age distribution, family composition, etc.). Based on GIS's strong incorporation ability, it is easy to obtain the demographic information for any scale of area, from a single postal code area to a town or even a whole country.

In GIS, there are three ways to delineate an area. The first is to give out a centroid and an absolute distance. A circle area around the centroid is produced by this method.

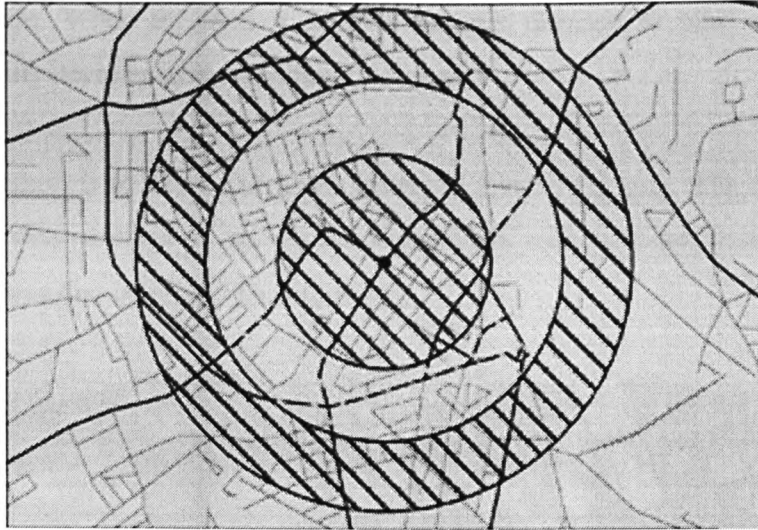


Figure 3.2.1 Trade Areas Defined by Distance Radius Circles

The second method should also point out a centroid, but a relative distance (drive time) is needed instead of an absolute distance. The delineated area usually has a random pattern. The reason is that for a fixed time interval the drive speeds to different directions and on different roads are not the same.

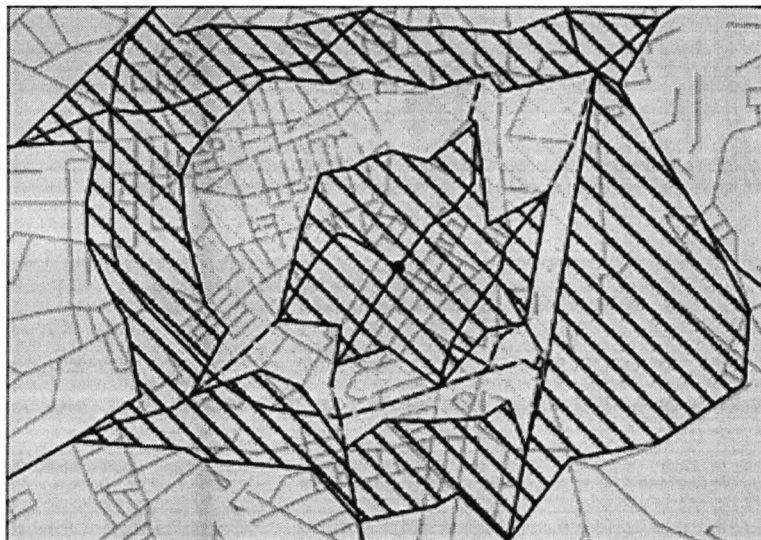


Figure 3.2.2 Trade Areas Defined by Drive Time

Here, a centroid is a weighted centre and is not necessarily the same as the physical centre. When the area is defined by absolute distance, the centroid is the same as the

physical centre. When the area is defined by time distance or other measures, the centroid usually deviates from the physical centre.

The third method is to use a computer mouse to draw a polygon. The most common polygons are those defined by the specific line objects, such as streets, rivers, and so on. Below is an area that is defined by four streets.



Figure 3.2.3 The Area Defined by Streets

As long as an area is defined, GIS can show the data information and geographical information in that area.

3.3 Consumer Spatial Data and GIS

Consumer spatial data is essential to GIS, particularly to marketing oriented GIS. It can be classified into three groups/levels. They are Census data, Geodemographics and Lifestyle data.

3.3.1 Census data

Census data forms the basic foundation for consumer spatial data. It is available from the statistics bureaux of countries. In the UK, it is provided by the Office of Population Censuses and Surveys (OPCS), now the Office of National Statistics. There are two sets of data. One is the 100% census survey, which is conducted every ten years. The latest version is the 2001 survey. Another is the 10% sample data, which is conducted between the censuses and acts as the necessary updating for some demographic domains.

In Canada, the census data is provided by Statistics Canada. The Census in Canada is conducted in five-year intervals. When the survey is conducted, most households are given a general questionnaire. A selected sample containing 20% households is given a more detailed questionnaire. The current available version is the 2001 Census.

The typical variables collected in a census are: Composition of people (in different aspects such as age / sex / marital status / social class / ethnicity); Composition of family (number of persons in a family, with or without children); Income (Personal and households); Employment status; Job categories; Estate ownership (house, car); etc. A typical census database contains over 1000 variables.

Census data can be integrated into a GIS system to show a thematic map, which can give people a broad view about the targeted area. Following is a map of Canada with the average household income from the 1996 Census:

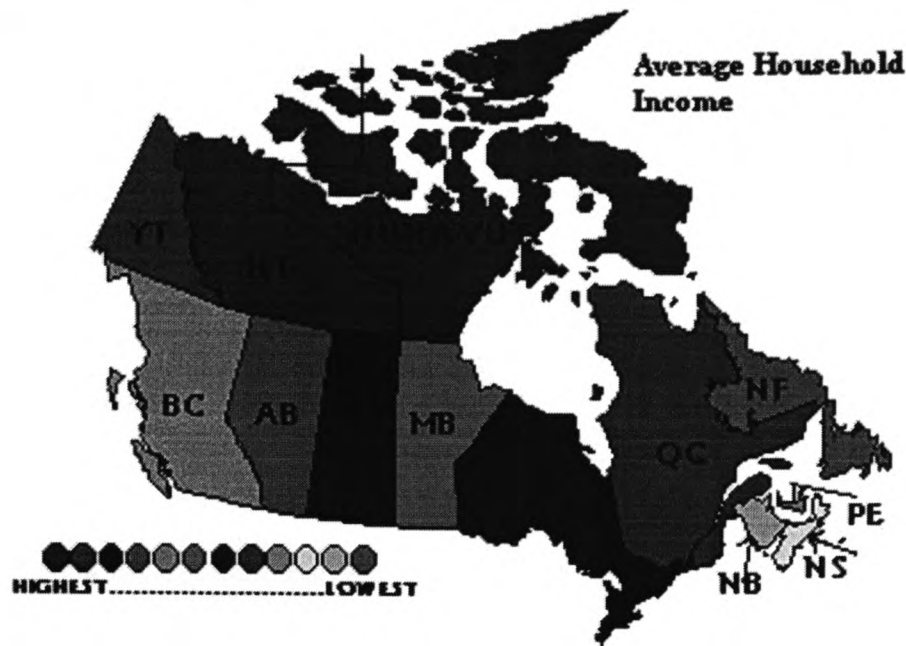


Figure 3.3.1 Average Household Income by Province/Territory in Canada
(Based on 1996 Census)

The above map indicates that two rural territories, Northwest and Yukon, have the highest average household income. Among the southern provinces, Ontario is the wealthiest.

3.3.2 Size of the Neighbourhood

The consumer spatial data is not only related to its data source, but is also highly related to the neighbourhood size applied by the data source. A suitable neighbourhood size should be capable of classification and meet the statistical analysis requirements. There are two types of neighbourhood size systems in most countries: the postal and census systems.

Postal System

In the postal system, the base unit that represents where people live is the postal code, used both in Canada and the UK (in some other countries, such as America, it is called the zip code). The average urban postal code size is about 15 households. In rural areas, the postal codes are much bigger, containing about 5000 households. There are 1.7

million (year 2001) such postal codes in the UK. In Canada, the current figure is about 800,000.

In the UK, postcodes are alphanumeric references comprising an outward code of 2-4 characters and an inward code of 3 characters. For example:

PO16	7DZ
outward code	inward code

The postcode is structured hierarchically, supporting 4 levels of a geographic unit (www.nationalstatistics.gov.uk/geography, February 2003):

- Postcode area (124 areas, e.g. PO)
- Postcode district (2933 districts, e.g. PO16)
- Postcode sector (9737 sectors, e.g. PO16 7)
- Unit postcode (1.7 million approx, e.g. PO16 7DZ)

City or town (the official name used by the Canada Post is “municipality”) is the next highest level of the neighbourhood size. Because of various spellings, name changing and continues amalgamation, this level of size is not consistent. One address can be assigned different city/town names.

For example, there is an area in Toronto, where the FSA (Forward Sortation Area) is M2N. Three city names are used by the residents in the area: Toronto, North York and Willowdale. They are all officially recognised by Canada Post. This is because the community name used by the post office is called Willowdale, but the municipality name defined by Statistics Canada is North York. In 1998, the city of Toronto and other five other cities (including North York) were merged together to form the Metro Toronto.

Because of the situations as above, the city name should always be used with care. Similar observations also apply to the UK system.

Province (in Canada) or County (in the UK) is the next level before the country itself.

Census System

Another neighbourhood size system is defined and used in the census. In the UK, there are two base units: Enumeration District (ED) and Output Area (OA). The average size of EDs is about 200 households.

For the previous census (1991 or earlier), the base output geographic area is ED. The 2001 Census introduced the use of OA. OAs are designed to have approximately similar populations and be as socially homogenous as possible (based on tenure of household and dwelling type, as stated on the Census form). Urban/rural mixes are avoided. In other words, OAs consist entirely of urban postcodes or entirely of rural postcodes. OAs are smaller than EDs and so allow for a finer resolution of data analysis. The average size is 125 households.

In Canada, the unit is called enumeration area (EA). The average EA size is about 200 households. Currently across the country there are 50,000 EAs. The EA-Postalcode relation is a little bit complicated in Canada: in urban areas, normally an EA contains several postal codes, but in rural areas, a postal code consists of several EAs.

Comparison and Linkage of the Two Systems

As indicated, postcodes form a compact geographic reference with which the public and businesses are familiar. Linking postal geographies to other geographic units is far from straightforward though as:

- Postcode boundaries are not contiguous with other geographic boundaries. If a unit postcode straddles a ward (or higher level) boundary, it has to decide to which ward to allocate the data.
- Postcode boundaries are subject to continuous change due to new addresses, single addresses acquiring large user postcodes as mail volume increases, and the need to restrict the number of addresses per unit to less than 100. Areas can also be recoded

and a code can be re-used in a different place after just two years. Continuous monitoring is therefore required to avoid data misallocation.

Most consumer spatial data is from the census, which is originally available at the ED/OA or EA level. But, because the common consumer geographic data is postal code related (typically reflected by the mailing address), it is more convenient when the data is calibrated into postal code level. To convert from census unit to postal code unit, a special file, called PCCF (Postal Code Conversion File), must be used.

Selecting a suitable neighbourhood size is essential to spatial analyses. If the size is too small, such as defined by an ED/OA/EA or postal code, much larger computer memory and longer computation time are required and, more importantly, the figures based on this kind of unit are too variable. It is typical, by using the incorporation ability of GIS, to merge the base units together to get the required information based on a larger level size.

3.3.3 Geodemographics

The census data from these bureaux are just the raw data and they are only available at the ED/OA/EA level. This, as discussed before, does not match with the people's daily address system. Also, an average of 150~200 households unit sometimes is still too big and diverse for a micro economic study. It is often found that in one ED/OA/EA located in the urban area there are several older, low-rise apartment buildings. Just around the corner there are detached homes with well-kept gardens and new cars in the driveway. Opposite the corner can be found a crowded street of semi-detached homes. Each of these different areas is represented by a unique postal code, and contains very different types of people. Unsurprisingly, targeting this ED/OA/EA as a whole will only produce poor results.

To fill the gap between the original census data and the actual requirements, another consumer spatial data category, geodemographic data, is widely used.

Geodemographic data incorporates demographics with the geographic (location) information. It is also known as geo-demographic data. From the geo-demographic data, researchers can analyse the consumers in the target areas by where they live.

Typical demographic data is produced from the census data combined with other information such as credit ratings, into a cluster algorithm to form the neighbourhoods. The neighbourhood size in the UK is around 150 households. The basic assumption is that two people living in the same neighbourhood are more likely to be similar than two people chosen at random.

Thirteen companies are now registered in the UK to use census data to provide geodemographic products. In the following table, Birkin and Clarke (1998) classified these companies into three groups:

- Data focus: Those whose interests main lie in reselling the data in a more user friendly form than raw census data (adding Windows environment, adding a mapping package, or providing a link to postal geographies).
- Geodemographic focus: Those who convert the raw census data into area typologies using their cluster algorithms.
- Analytical focus: Those whose primary interests lie in adding value to the census data through the provision of some kind of modelling capability.

Table 3.3.1 Categorization of U.K. Companies Registered to Use Census Data

Data Focus	Geodemographic Focus	Analytical Focus
Capscan Ltd. Chadwyck-Healey Ltd. Claymore Services Ltd.	CACI [ACORN] CCN Marketing [MOSAIC] CDMS Ltd. [SUPERPROFILES] EuroDirect Ltd. [Prospects And Neighbours] Equifax Ltd. [Define] Infolink Decision Svs. Ltd. [Images] Pinpoint Analysis Ltd. [PIN/FINPIN]	The Date Consultancy GMAP Ltd. SPA Marketing Systems

Source: Mark Birkin and Graham Clarke, 1998

Among these products, the most popular geodemographics databases are:

- CACI's ACORN. (A Classification Of Residential Neighbourhoods) which divides up the entire UK population in terms of the type of housing in which they live. For each of these areas, a wide range of demographic information is generated and the system affords the opportunity to assess product usage patterns, dependent upon the research conducted within national surveys. There are 54 separate groupings including, for example: (i) wealthy suburbs, large detached houses; (ii) private flats, elderly people, (iii) gentrified multi-ethnic areas, (iv) rural areas, mixed occupations, (v) council areas, residents with health problems.
- CCN's MOSAIC. This system also analyses information from various sources including the census, which is used to give housing, socioeconomic, household and age data; the electoral roll, to give household composition and population movement data; post code address files to give information on post 1991 housing and special address types such as farms and flats; and CCN files/Lord Chancellor's office to give credit search information and bad debt risk respectively.
- PINPOINT. Pinpoint Identified Neighbourhoods utilizes information from disparate sources and overlays this with the Ordnance Survey to target individual houses the 150 houses denoted by an enumerated district.
- FiNPiN. Financial PIN, uses data not only from the census, but also from the Financial Research Survey which comprises 30,000 respondents. Information concentrates upon details of financial holdings and usage patterns, so that FiNPiN neighbourhoods are able to describe financial activity as well as demographics.

In Canada, such kind of commercial databases are:

- PSYTE (Provider: Compusearch). PSYTE is a market segmentation system based on the census. PSYTE provides marketers with distinct customer segments that incorporate hundreds of products, automobiles, activities and media habits. It is the first Canadian segmentation system to incorporate behavioural data in addition to

demographic and socio-economic variables. PSYTE databases are available at two summary levels:

- PSYTE – Clusters: This database has 60 clusters that are organized into 15 major groups. Each cluster is associated with one of four settlement types: Urban with 23 clusters, Suburban with 17 clusters, Towns with 8 clusters and Rural with 12 clusters.
- PSYTE – Groups: This database has 15 major groups. Each group is associated with one of four settlement types: Urban with 6 groups, Suburban with 5 groups, Towns with 2 groups and Rural with 2 groups.
- MOSAIC (Provider: Generation 5). MOSAIC segments Canadian households by similarities in product purchasing, lifestyle, and demographic characteristics. Most importantly it is compiled at the 6-digit postal code level. MOSAIC includes actual consumer purchase data, not just demographics. Totally there are 20 Groups and 150 sub-Segment Types.

3.3.4 Lifestyle data

Besides the basic demographic data, some organizations and companies try to provide more detailed consumer behaviour databases. These databases are collected from large-scale surveys. Questionnaires are distributed to sampled households to let them fill about their demographics (age, sex, household size, etc.); socioeconomic characteristics (occupation, educational attainment, and, crucially, income); and consumer lifestyles (including hobbies and expenditure characteristics of households).

The most commonly used lifestyle databases in the UK and North America are:

- Computerized Marketing Technologies (CMT)
- National Demographics and Lifestyles (NDL)
- International Communications and Data (ICD)
- POLK

- Survey of Household Spending (SHS)
- Household Income, Facilities and Equipment (HIFE)

The main advantages of lifestyle databases are the additional variables they contain (such as income) and that they identify named individuals with known characteristics (see discussion in the next section). The main drawbacks of lifestyle data sets are their expense, considerably more than conventional geodemographic packages, and that the data will not be available for individuals who have not responded to the questionnaires of the database provider (Mark Birkin and Graham Clarke, 1998).

3.3.5 Other consumer spatial data sources

One of the problems of using census data as the consumer spatial data is that the time interval between each version is too long. The minimum is five years. During this time, the consumer structure in the areas may change quite a lot. For example, in Canada the household moving rate is about 5% per year. In a five year span, the reliability of the census data is less than 75%.

Another problem is that because of privacy issue, the published census data will skip some areas. For example, the Statistics Canada will remove the data from any EAs having 15 households or less and round the values in each EA to 5 or 10 (e.g., if the actual population of age 10~14 is 14, then the published figure will be 15. If it is 12, the published figure will be 10).

Because of the above reasons, some non-census data sources become useful. Following are some main sources popularly used in Western countries:

- Telephone Directory. In North America general household information (name, address, and telephone number) are public. If households do not want to be listed, they have to pay for the request. So the list rate is very high, over 90% of the actual households. The data is updated frequently. Some companies can update monthly basis. From this kind of data source, analysts can obtain consumer information such as the number of households, dwelling type (single family dwelling unit vs. single

family dwelling unit), ethnicity (identified by the surname). These data are more accurate than that of a five-year-old census.

- Tax Filer Database. It provides detailed information on household income and financial expenditures at the Enumeration Area (EA) and postal code levels.
- Electoral Roll. It can provide the additional information of the voters such as, family composition, the voters' status, length of residency, etc., and their location (address) as well.
- Credit Activity / Bad Debt Data. It records the credit applications and bad debt cases. This kind of data can be used to assist the judgement of the financial status of a target group of people.
- Market Research Data. This kind of data is produced by some market research organisations. One of the popular data used in the UK is from the Financial Research Survey (FRS), which provides the respondents' details such as their financial holdings and usage (e.g., bank accounts held, share holdings, credit cards, pensions, insurance, etc.). In Canada, companies such as BBM, PMB and NadBank provide this kind of data.
- Business Information. The above sources are all related to the end consumers. There are many information sources that are related to specific businesses. Though these data do not belong to demographics, they are very important sources for marketing GIS.
- Postal Walk Databases. Householder Data, Postal Code Address Data and Delivery Mode Data.

Two examples of business information available in the UK are:

- Main multiples database from IGD (Institute of Grocery Distribution), giving the characteristics (size, number of checkouts, accessibility in terms of car park area, etc.) and the location for all the outlets of main multiple grocery groups.
- Independent Retailer database from WASP Database Ltd., which provides over 65,000 independent retailers information.

These data can be employed as the base of customer/competitor analysis in marketing GIS.

3.4 Components of GIS

GIS consists of five key components: Hardware, Software, Data, People and Methods.

Hardware

Hardware is the computer system on which the GIS software will run. The choice of hardware systems range from Personal Computers to Super Computers. The computer forms the backbone of the GIS hardware through which gets input using a Scanner or a digitizer board. A scanner converts a picture into a digital image for further processing. The output of a scanner can be stored in many formats e.g. TIFF, BMP, JPG etc. A digitizer board is flat board used to produce vector arrays of given map objects. Printers and plotters are the most common output devices for a GIS hardware setup.

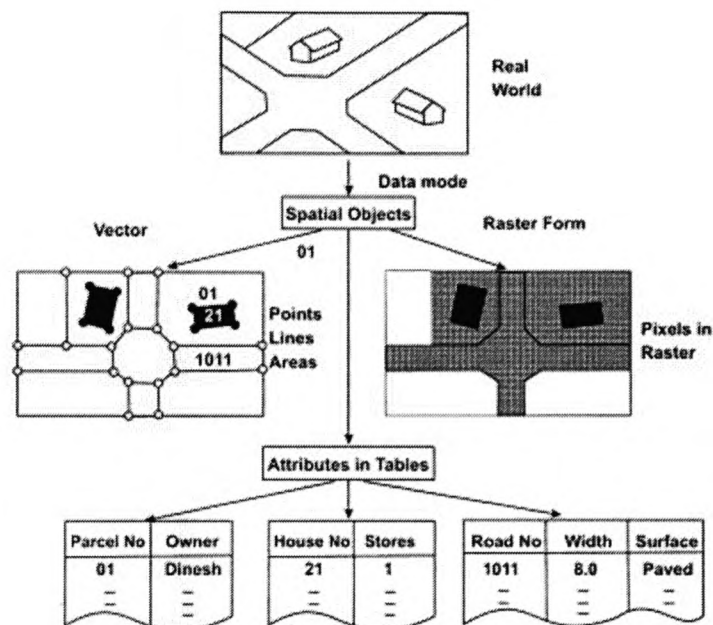
Software

GIS software provides the functions and tools needed to store, analyze, and display geographic information. GIS software in use are ArcView, ILWIS, MapInfo, ARC/Info, AutoCAD Map, etc. The software available can be said to be application specific. When low cost GIS work is to be carried out, desktop GIS is the suitable option. It is easy to use and supports many GIS features. If the user intends to carry out extensive analysis on GIS, ARC/Info is the preferred option.

Data

Geographic data and related tabular data can be collected by the organisation or purchased from a commercial data provider. The digital map forms the basic data input for GIS. Tabular data related to the map objects can also be attached to the digital data. A GIS will integrate spatial data with other data resources and can even use a DBMS, used by most organizations to maintain their data and to manage spatial data.

The following diagram shows how data from the real world is converted into a GIS system:



People

Most definitions of GIS focus on the hardware, software, data and analysis components. However, no GIS exists in isolation from the organisational context, and there must always be people to plan, implement and operate the system as well as make decisions based on the output. GIS projects range from small research applications where one user is responsible for design and implementation and output, to international corporate distributed systems, where teams of staff interact with GIS in many different ways.

Method

Above all, a successful GIS operates according to a well-designed plan and business rules, which are the models and operating practices unique to each organization. There are various techniques used for map creation and further usage for any project. The map creation can either be automated raster to vector creator or it can be manually vectorized using the scanned images. The source of these digital maps can be either maps prepared by any survey agency or satellite imagery.

Chapter 4 Location Model for Cash & Carry / Warehouse Club

The literature review in Chapter 2 has found that there are diverse methods and models available and applied in retail location analyses. However, regarding the research object, Cash & Carry / Warehouse Club trade sector, what method / model meets its characteristics remains as an unanswered question.

4.1 Model Selection

In the conventional retail location analyses, two types of models have been widely used: Gravity and Regression models.

Rooted in the model mechanism and the procedure of calibration, the gravity model has the following weaknesses as commented by Heald (1973) and Rogers (1992):

- Gravity models involve detailed field survey. If there are several potential sites in different locations, then the field survey must be conducted the same number of times individually. It is very time consuming indeed;
- Beyond population counts, distance relationships and competition, gravity models offer only limited understanding of the factors influencing the performance of existing stores;
- The successful application of gravity models requires reliable approaches for estimating spending potential, and the attractiveness - or sales - of individual stores and shopping centres;
- Gravity models have difficulty in considering the impact of differential mobility levels;
- The model requires more analyst judgements than regression and other techniques.

Based on the observed weakness of gravity models, Heald (1972) pointed out that these kinds of models “have been mainly applied to assessing consumer distribution of expenditure between shopping centres in contrast to individual stores”.

On the other hand, a survey conducted by Simkin *et al* revealed that the regression model had been largely used by the grocery retailers (Simkin, 1985).

The advantages of regression models are:

- Allow systematic consideration of trading area factors (demographics, traffic, etc.), store specific elements (store performance, size, attractiveness, etc.) and competitiveness in a single framework;
- Provide a statistical method to help the analysts identify the importance of these factors. By getting rid of the non-significant factors, the model can be not only simpler, but also closer to the real situation;
- Suitable for multiple outlets environment. The complexity of the model will not increase dramatically with the number of outlets (a vital weakness for MCI and location-allocation models);
- The qualitative managerial judgements can easily be integrated into the model (for example, adjusting the weights for certain variables). This, according to some researchers (Durvasula, 1992), will improve the accuracy of the model and lead the model to be more easily accepted by the management.

Cash and Carry / Warehouse Club, as discussed before, belongs to the grocery sector. Most of these companies have multiple outlets (called depots in the UK). Hence, the multiple regression model has been chosen in this thesis.

4.2 Type Selection

The real relation between a store's performance and its factors is very complicated. However, by glancing at the literature, in general two types of regression models have been employed in retail researches. The first is multiple linear regression (Davies 1973, Heald 1972), which can be expressed as:

$$Y = a_0 + a_1 * X_1 + a_2 * X_2 + \dots + a_k * X_k$$

The second one is the multiple exponential regression (Morphet 1991), which has the format:

$$Y = e^{b_0} * X_1^{b_1} * X_2^{b_2} * \dots * X_n^{b_n}$$

In the above equation, e^{b_0} can be replaced by a constant B_0 .

The choice between these two types of models should be decided by the real situation. Actually, it is very important that research be directed by the data and the situation, not the pre-decided model specification. In this thesis both types are analysed and compared.

4.3 Criteria for Measuring Goodness of Fit

Suppose a multiple regression model:

$$Y = \beta_0 + \beta_1 * X_1 + \beta_2 * X_2 + \dots + \beta_k * X_k + \varepsilon$$

has k independent variables and is fitted from a sample with n observations.

The fitted model can be expressed as:

$$Y = \hat{\beta}_0 + \hat{\beta}_1 * X_1 + \hat{\beta}_2 * X_2 + \dots + \hat{\beta}_k * X_k$$

Where $\hat{\beta}_0$, $\hat{\beta}_1$, $\hat{\beta}_2$, •••, $\hat{\beta}_k$ are the estimations of the coefficients.

For the above model, the following expressions exist:

- The mean of Y:

$$\bar{Y} = \sum_{i=1}^n Y_i / n$$

- The degree of freedom:

$$Fr = n - (k+1)$$

- The sum of squares due to errors:

$$SSE = \sum (Y_i - \hat{Y}_i)^2$$

- The sum of squares due to regression:

$$SSR = \sum (\hat{Y}_i - \bar{Y})^2$$

- The total sum of square of deviation:

$$\text{Total SS} = \sum (Y_i - \bar{Y})^2 = SSE + SSR$$

Based on the above relations, the following parameters are usually constructed and used to judge the fitness of the model:

- \underline{R}^2 : Multiple coefficient of determination which represents the percentage of the sample variation being attributed to, or explained by, the k independent variables in the model.

$$R^2 = 1 - \text{SSE} / \text{TotalSS} = \text{SSR} / \text{Total SS}$$

R^2 is often used as a primary measure to judge the fitness of the model. However, the drawback of R^2 is that it keeps increasing if more variables are added into the model. These variables might have very little or no contribution to the model. In theory, if the number of variables k is close to the number of observations n , R^2 will reach to 1. It forms a false high fitness. For this reason, many authors (Mendenhal *et al*, 1989 and Morphet, 1991) pointed out that R^2 should not be taken as a good measure. To solve the problem, a new measure, adjusted R^2 , has been popularly used which can be expressed as follows:

- $R^2(\text{adj})$: Adjusted R^2 by the degrees of freedom.

$$R^2(\text{adj}) = 1 - \text{SSE} * (n-1) / (\text{TotalSS} * (n-k-1))$$

$R^2(\text{adj})$ remedies the above problem by trading off the decrease of the SSE due to more variables being added and the decrease of the denominator caused by the larger k value. So only those variables being significant enough, i.e., having some contribution to the model's fitness, can cause $R^2(\text{adj})$ to increase.

The difference between R^2 and $R^2(\text{adj})$ also gives some information about the model's fitness. If $R^2(\text{adj}) < R^2$, it indicates that either there are some other significant variables that have not been selected into the model or at least one of the factors in the model contributes very little and therefore should be removed from the model.

In the following analyses, $R^2(\text{adj})$ is chosen as the main parameter to decide the model's fitness. The difference between $R^2(\text{adj})$ and R^2 is used to assist in the judgement of the factor selection.

- Global F Statistic: Test of the overall utility of the model.

$$F = \text{SSR} * (n-k-1) / (\text{SSE} * k)$$

The value of the F statistic can be used to test the hypothesis:

$$H_0: \beta_0 = 0, \beta_1 = 0, \beta_2 = 0, \dots, \beta_k = 0$$

H_a : otherwise.

Where $\beta_i = 0$ means that the i th variable has no contribution to the fitness of model. $\beta_i > 0$ means the i th variable is positively related to the dependent variable (the store turnover in this analysis). $\beta_i < 0$ indicates the negative relation between the two sides.

While $R^2(\text{adj})$ and R^2 are employed to measure the explanation level of the model, the global F statistic can be used to test the significance level of all the factors in the model. If F is greater than F_α , a fixed value decided by the degree of freedom and the value of α , then the probability of rejecting H_0 and accepting H_a is $(1 - \alpha)$. The confidence level of considering the factors in the current model being significant is $(1 - \alpha)\%$.

α is also expressed as $\text{Prob}(F > F_\alpha)$ which is available in most statistics tables or packages. $\text{Prob}()$ is called p-value in the following analyses. In this research, the global p-value has been chosen to be 0.05. Therefore, a high confidence level, 95%, has been selected to justify the model's significance.

- S^2 value: An estimate of the error standard deviation σ_ϵ :

$$S^2 = \text{SSE} / (n - k - 1)$$

S^2 is used as an assistant parameter of judging the model's fitness.

- Test of the significance for individual factors:

The hypotheses:

$H_0: \beta_i = 0$ (i th variable has no contribution)

$H_a: \beta_i \neq 0$ (i th variable is significant and can not be ignored)

are usually used to test the significance level of individual factors X_i . Either the F statistic or the t statistic can be employed for the test.

The t statistic is constructed as follows:

$$t = \hat{\beta}_i / S_{\beta_i}$$

where S_{β_i} is the standard deviation of β_i . This is also available in most statistics package outputs.

Usually a two-tailed rejection region is employed for t test:

Reject: if $|t| > t_{\alpha/2}$

In the following analyses, $\text{Prob}(|t| > t_{\alpha/2})$ will be used as a criterion to decide which variable needs to be added, which variable has to be dropped. In the variable filtering procedure, it is necessary to lower the significant level a little in order not to miss any potential explanatory variables. Based on this consideration, $\text{Prob}(|t| > t_{\alpha/2}) = 0.10$ is used in the variable filtering procedure..

4.4 Statistics Package Selection

Table 4.4.1, quoted from Mendenhal *et al* (1992), lists the regression features of four popular statistics packages:

Table 4.4.1 Regression Features

Package Name	Type of Output	Confidence Intervals for Mean of Y	Prediction Intervals for Particular Values of Y	R or R^2	Residual Plots
BMDP	Standard	No	No	Both	Yes
MINITAB	Standard or stepwise	Yes	Yes	R^2	Yes
SAS	Backward, forward or stepwise	Yes	Yes	R^2	Yes
SPSS	Standard or stepwise	No	No	Both	Yes

From this table it can be observed that purely for regression analysis, MINITAB is as good as the other packages. The advantages of using MINITAB are:

- MINITAB is available at hand.
- MINITAB is a smaller package and much more easily to be integrated into a system.

The weakness of MINITAB is that it is a DOS version that is not preferred by most end users who are used to the Windows environment. However, with a modelling interface, which will be described in Chapter 9, this weakness can be turned into an advantage: regression analysis procedures can be hidden behind the screen so they can be seamlessly integrated into a system.

A typical MINITAB regression output contains the following fitness parameters:

- Both R^2 and $R^2(\text{adj})$, printed as R-sq and R-sq(adj);
- Global F statistic with the probability $\text{Prob}(F > F_\alpha)$, printed in “Analysis of Variance” section under the columns of “F” and “p” respectively;
- Individual t ratio and the $\text{Prob}(|t| > t_{\alpha/2})$ for each factor in the model, listed in the columns of “t-ratio” and “p” in the section just under the regression equation;
- Estimation of variance S.

4.5 Summary

One of the major disadvantages of Gravity related models is its high cost due to necessary multiple location fieldwork. On the other hand, Regression models have been proved to be especially suitable to multiple outlet retailers.

When using the regression model in location analysis, the regression method is the only function required in the study. The package, MINITAB, can fully meet the requirement. Another additional advantage to using MINITAB is that it can be easily integrated into a location decision system proposed in later chapters. The other packages either are too expensive, or difficult to integrate as a component of the decision system because these packages are designed as stand-alone packages.

Chapter 5 Trade Area Analysis

The quality of location analysis will not only rely on method or model selection, but will also be largely affected by the trade area definition. An improperly defined trade area will lead to false data being employed and the output from this kind of data certainly will not be correct. How to define a trade area and what is the proper measure for the research object – Cash & Carry / Warehouse Club – are the topics discussed in this chapter.

5.1 Definition of Trade Area

A trade area is a contiguous geographic area that accounts for the majority of a store's sales and customers. It can be divided into three zones:

- Primary zone: The area from which the store derives 60~65% of the customers;
- Secondary zone: The area of secondary importance in terms of customer sales, generating about 20% of the store's sales;
- Tertiary zone: The area that includes customers who occasionally shop at the store.

Further a trade area can be defined as a contiguous geographic area with the following specifications (Heald, 1972):

- A function of outlet size;
- Significant difference between urban areas and rural areas;
- A function of the number of "key-traders";
- Inverse relation to the population density;
- A function of social class primarily due to the relation between income, car ownership and mobility.

5.2 Factors Affecting the Trade Area

Common factors defining trade area:

- **Store characteristics**
 - Type: Grocery, Department or Specialty; Independent, Franchise or Multiple outlet chain;
 - Image: Famousness, Size, Service or Visibility;
 - Accessibility: Parking, Bus stop, Convenience to main road or highway.
- **Demographics**: Density of total population or special group of people (with certain income, employed or unemployed, owner or renter, family with or without children, ethnicity, etc.)
- **Physical Barriers**: Natural barrier (river, lake, mountain, etc.), Roads, Traffic flow.
- **Competition**: Number of competitors, Market share of the competitors.

The size of trade area will also be decided by the significance of a store (Thrall and Valle, 1997):

- The “destination stores” are those in which the merchandise, selection, presentation, pricing or other unique feature act as a magnet to customers; customers choose these kinds of stores as their shopping destination and are willing to travel longer distance;
- The convenience stores or other small stores are those whose services customers use based mainly on convenience. The trade area will be much smaller;
- The third type of store is called “parasite store”. These stores do not create their own shopping traffic. Their trade areas are determined by the dominant retailer in the area.

A trade area can be either overlapped or exclusive, and this depends on whether the store is owned by a multiple outlet chain or by an independent or franchised retailer.

Chain retailers tend to maximize market share by saturation (Langston *et al*, 1997). A new store will be opened as long as the marginal revenue is greater than the marginal cost. For example, Home Depot, a giant home hardware retailer in North America, believes that the solution to an under-performing store is to build another store in the same area. The reason is that, according to Home Depot, the under performing store might be overcrowded, offer poor service, have a hard time maintaining stock, etc. Adding another store would ease these problems. Also, some costs, such as advertising, will not increase when a new store is opened. Thirdly, the saturation will increase the company's competitiveness and force some competitors to quit the market. Finally, it is better to have two stores producing \$75 million each than one store producing \$100 million.

Independent or franchise operators want to maximize their own profits, instead of the market share. For this reason, they often prefer the trade areas to be their exclusive territories.

5.3 Methods of Delimiting the Trade Area

A defined trade area greatly affects the quality of the retail analysis. Some authors have tried to test different methods in order to properly define a trade area. Currently there are several methods. The most commonly used methods are conventional method, customer spotting and the application of demographic databases.

Conventional method

The conventional method is based on the managerial experience and the statistics of existing retail stores. Normally a survey will be conducted on a selected sample of store managers to let them define the trade area for their own or proposed stores.

Some published trade area sizes are:

- Restaurants: “Consumers typically travel no more than 20 minutes to patronize a ‘sit down’ restaurant (Thrall 1990). Grant Ian Thrall chose 5 miles radius, based on the average urban travel speed of 15 miles per hour, as the trade area for Red Lobster Restaurant” (Thrall 1998);
- Cash and Carry: Meidan (1992) pointed out that, from his “Cash & Carry Customer's Shopping Habits” research, the maximum distance for a customer to visit a C & C depot was 25 miles.

Conventional method is the simplest among three options. But it is more subjective and also is affected by the sample size and the survey response rate.

Customer spotting method

Some researchers (Heald, 1972) used a simple but more objective method: First, all the customers’ addresses are collected. The techniques used for this purpose are:

- Data from credit card or cheque purchases.
- Data from some loyalty programs.
- Car licence plates collected in the car parking.

Second, the addresses are plotted on a map. Finally, an envelope that accommodates 90% of the customers is drawn and used to define the trade area border.

The advantage of this method is that it can pinpoint the actual customers. However, its disadvantages are: first it needs fieldwork that will be expensive and requires timing. Second, the sample size is normally limited; it cannot represent the actual population composition in the area.

Applying a demographic database

Some stores have certain types of population as their key customers such as, families with children for toy stores, homeowners for home hardware stores, etc. By knowing

this, location analysts can acquire consumer data from a demographic database. The data will be attached to the base unit (EA, ED/OA or postal code, as discussed before). These units can be plotted on a map and the trade area can be identified.

Using a demographic database is much more convenient and inexpensive. The data is mostly obtained from the census and published information. Retailers only have to pay a little money to acquire the data.

Another advantage of this method is that it makes the trade area automatic configuration become possible. A demographic database can be taken as continuous on a geographic dimension. That is, the analysts can inquire into the consumer data for any size of area they want. This ability, as proposed in the later chapter, is the key for trade area auto-configuration.

5.4 Summary

A proper defined trade area is very vital to the quality of location analysis. Theoretically, trade areas for different outlets in a retail chain are different. The best way is to use demographic data and a suitable tool (such as GIS) to automatically configure trade areas for each outlet. However, if the conditions are limited (the unavailability of a national demographic database, the unavailability of an in house GIS), the conventional method can be used to decide a trade area for all the outlets. This is a simplified method that is based on managerial experience and previous research results. In practice, this method has proven to be an effective solution.

Chapter 6 Development of the Model for Cash and Carry

6.1 Introduction

In the previous chapters, the theories, methods and tools used in retail location analysis have been studied. Based on the study, a method of model development for a particular retail sector – Cash and Carry / Warehouse Club – has been developed. To test the method, this chapter is going to use the data collected from a British Cash and Carry chain to calibrate a practical model.

The company is one of the biggest Cash & Carry traders in the UK with 71 depots in the country. The total turnover in 1994 was more than £1.4 billion and the total depot size was about 4,000,000 ft².

The company had experienced high pressure from the multiple outlet supermarkets. To get the true competitive advantage under the changed environments, starting in 1993, the company collaborated with a university in Manchester in conducting a large project investigating the Cash & Carry market, and constructing development strategies. A site location model was part of the project.

6.2 Trade Area

Trade Area Measurements

In Chapter 3, two main types of area measurements, in terms of distance and drive time, have been reviewed. Both are available in most GIS systems and used in retail researches. Drive time has the advantage of taking the time spent on the road into account. It is the better measurement for retailers whose customers are mainly car based. For Cash and Carry, most customers are convenience storeowners and caterers. They visit the depots by cars. Therefore drive time is a more preferable measurement to delineate the trade area.

Trade Area Size

Ideally, using a GIS aided auto-configuration could produce a better trade area size. However, during the time that this model was calibrated, an in house GIS was not available. In order to determine a trade area size close to the real one, the company conducted a survey of the managers in its individual depots. Their view was that half an hour drive time was considered as a commonly accepted range for a Cash & Carry depot.

A similar conclusion was also found in some prior surveys. Meidan (1992) pointed out that, from his “Cash & Carry Customer's Shopping Habits” research, the maximum distance for a customer to visit a C & C depot was 25 miles. Such a distance would, in the UK and in all likelihood, be further than individuals would travel – under the spatial density of population in the UK.

6.3 Variable Selection and Data Collection

As a dependent variable, store performance can be expressed by several characteristics. Among them the store turnover is mostly accepted (Heald 1972, Craig and Ghosh 1984). The highest turnover with the goal to maximize competitiveness is one of the priorities of the collaborated Cash & Carry company. For this reason, depot turnover has been selected as the dependent variable in the model.

The independent variables, which are the potential factors influencing the depot turnover, can be grouped into three categories: Depot Characteristics, Trade Area Demand and Competitiveness.

The early research often introduced many independent variables into regression analyses. This kind of treatment has been criticised because it could cause overfitting and/or multicollinearity problems. Therefore, this method is not adopted in the research. Instead, the variables have been carefully selected and assessed before being entered into the regression analyses. The assessment is based on the results of existing research.

6.3.1 Depot Characteristics

There are many variables in this category: some are quantifiable, such as store size, rent and rate, number of staff. Some are qualitative, such as store rank, competitiveness, car park convenience, etc.

The store size had been identified as a significant predictor of retail performance by many authors (Davies 1973, Heald 1972, Morphet 1991). Therefore, this variable is selected first.

The next quantitative variable called “number of full time equivalent employees” is selected because it was also identified as a significant contributor to the store performance (Peterson, 1993).

Derived from the results of Blattberg and Hoch’s research, which revealed that “the predictivity of the model was always found to be higher when including managerial inputs” (Blattberg and Hoch, 1990), two subjective variables are formed. They are Price Competitiveness and Depot Rank.

The reason for choosing “Price Competitiveness” is that, based on the early research, lower price was a key consideration for customers to select a Cash & Carry depot. It is usually listed as the number one factor (Meidan *et al*, 1992).

The variable “Depot Rank” is selected because it is common sense that many customers are attracted by this factor. The stores with better recognition and higher rank can attract more people. It is just like the “brand effect”: Famous brand products can attract more sales, even when their value- of-money is lower than the competitors.

The two subjective variables are evaluated and marked on a basis of 1 – 9 by a group of selected experienced managers. A total of 668 depot questionnaires, according to the list in *Pro wholesaler Cash and Carry Big Book* 1993, were mailed out. Four hundred and forty seven questionnaires were returned and used in this research. The number

difference was due to some specialists who were not interested in our research, some depots closed down, and a few non-responses.

Therefore, as a result the following depot characteristics had been chosen for the regression analysis:

Dependent Variable:

TURN -- Turnover of a depot, measured by the sterling pound in millions.

Independent Variables:

SIZE -- Depot size, measured by square feet;

RANK -- Depot ranking, 1 - poorest; 9 – brightest;

COMP -- Price competitiveness, 1 - uncompetitive; 9 - best value-of-money
in the area;

FTE -- Number of full time equivalent employees in a depot.

Altogether, four internal characteristics, i.e., TURN, SIZE, RANK, COMP, of 69 depots that belong to the researched object company have been collected (For some operational reasons, two depots' data are missing).

The total turnover, among 447 general C & C depots, was £7,137 m. The average turnover was £16.0m with the range from £0.5m to £67.0m.

Depot size ranged from 3,000 ft² to 185,000 ft². The average size was 46,818 ft². The total size summed to 20,927,450 ft².

Figure 6.1 shows that while the depot sizes spread widely from 3,000 ft² to 185,000 ft², nearly two thirds of them (284 in 447, 63.5%) were between 10,000 ft² to 50,000 ft² (See bar 2~5 in the following figure).

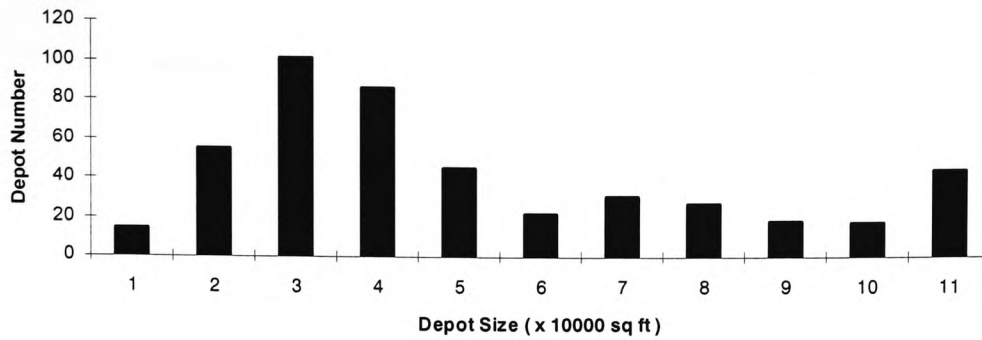


Figure 6.1 Depot Size Structure

6.3.2 Trade Area Demands

Although most direct customers are convenience storeowners and caterers, the real demand of a Cash & Carry depot is determined by the trade area consumer demographics. There are many demographic variables to choose from.

Among the variables, most have almost no relation or a very weak relation with the retail performance. According to published literature, the factors that did significantly influence retail performance were focused on:

- Total population in trade area (Heald 1972, Morphet 1991);
- Total expenditure (Davies 1973). This is highly related to population and only one of them can be used in a model;
- Percentage of economically active women (Morphet 1991);
- Percentage of the people in certain classes (Davies 1973, Heald 1972).

According to the Statistics Sector Data provided by IGD and FWD (Pro Wholesaler Cash & Carry Big Book 1993), the 1991 Cash and Carry customer split was:

Table 6.3.1 Cash and Carry Split

70% Grocery retailers
20% Caterers
10% Others

The split means that most direct customers are grocery retailers, such as the corner shops, which are considered as “convenience shopping stores”. These shops' consumers are those people who either have difficulty shopping a distance away (without private transportation facilities or elderly) or are busy at work without much time to shop away.

Based on the features of the collaborated company, three groups of people are considered possibly to affect the Cash & Carry turnover:

- Economically active women: they prefer to shop in a convenience store because they are too busy;
- Households without a car: they have no car to shop away;
- Old age pensioners: they are too old to shop away.

Also, according to normal experience, the average income level should be a factor affecting the retail turnover.

So far, the following consumer demographic variables have been selected:

- POPU -- Total trade area population;
- ACTW -- Percentage of economically active women;
- CARL -- Percentage of carless households;
- OAPS -- Percentage of old aged pensioners;
- INCM -- Average household income.

As pointed out before, the direct customers of Cash & Carry are the independent retailers and caterers. They play an intermediary role between Cash & Carry and the end consumers. The sales, size or number of these businesses reflect the direct requirement of a Cash & Carry depot. Based on the availability of the data, the variable:

CUST -- Number of independent retailers in the trade area

is also chosen as a candidate variable for the analysis.

The demographic information of 69 trade areas, relevant to the member depots of the researched object company, were requested and stored in the database.

6.3.3 Competitiveness

This aspect is the most difficult and arguable issue in retailing location research. This is not only due to the difficulty in defining groups of competitors (Should the multiple supermarkets be the competitors of Cash & Carry?), but also for lack of a suitable measurement to express the competition level.

From the existing literature (Davies 1973, Heald 1972, Morphet 1991, Simkin 1990), there are the following competitiveness measurements:

- Distance to the nearest competitor;
- Number of competitors in the trade area;
- Total of competitors' size or the other characteristics.

Based on the normal experience and Retail Gravity concept, the author believes that the competitiveness should be related not only to the competitors' number or their scale (size, turnover or the others), but also the distance from them to the object depot. That is, the more powerful the competitor, or the closer the competitor, the stronger the competition will be. On the other hand, no matter how strong, how big the competitor, if it is far away from the object store, the competition will be very weak.

Thus two competitiveness measurements, Distance Weighted Competitive Turnover (DWCT) and Distance Weighted Competitor Size (DWCS), are constructed and defined as:

$$DWCT_i = \sum_{j \in J(i)} TURN_{ij} / DIST_{ij}^{\gamma}$$

$$DWCS_i = \sum_{j \in J(i)} SIZE_{ij} / DIST_{ij}^{\gamma}$$

Where: $TURN_{ij}$: The turnover of j th competitor in Depot _{i} 's trade area;
 $SIZE_{ij}$: The size of j th competitor in Depot _{i} 's trade area;
 $DIST_{ij}$: The distance from j th competitor to Depot _{i} , the object depot;
 $J(i)$: The set of competitors in Depot _{i} 's trade area.
 γ : Distance weighted parameter decided by the fit of regression model.

$$\gamma \geq 0$$

DWCT and DWCS are the extensions of the competitiveness measurements used by previous researchers. When $\gamma = 0$, the special case where distance is considered having zero influence over the competition, DWCT and DWCS become the third group measurements summarized by Davies 1973, Heald 1972, Morphet 1991 and Simkin 1990, i.e., the total of competitors' size or the other characteristics.

As multiple supermarkets play a more and more important role in the retail market, they have formed a main challenge to the Cash & Carry business. However, the direct customers of the two sectors are different. In this case, whether multiple supermarkets should be taken as a kind of competitor remains unanswered. The best solution of this

question must come from the analysis results. Therefore, two kinds of competitors have been taken into account. One is the general Cash & Carry depots. Another is the main multiple supermarkets.

In the following analyses, DWCT and DWCS represent Cash & Carry Only competitiveness; MDWCS stand for Cash & Carry Plus Multiples competitiveness (The turnover data of multiple supermarkets was not available, so MDWCT is not used in the analysis).

6.3.4 Data Structure

In total, the relationship structure between Cash & Carry turnover and its possible factors can be illustrated as Figure 6.2:

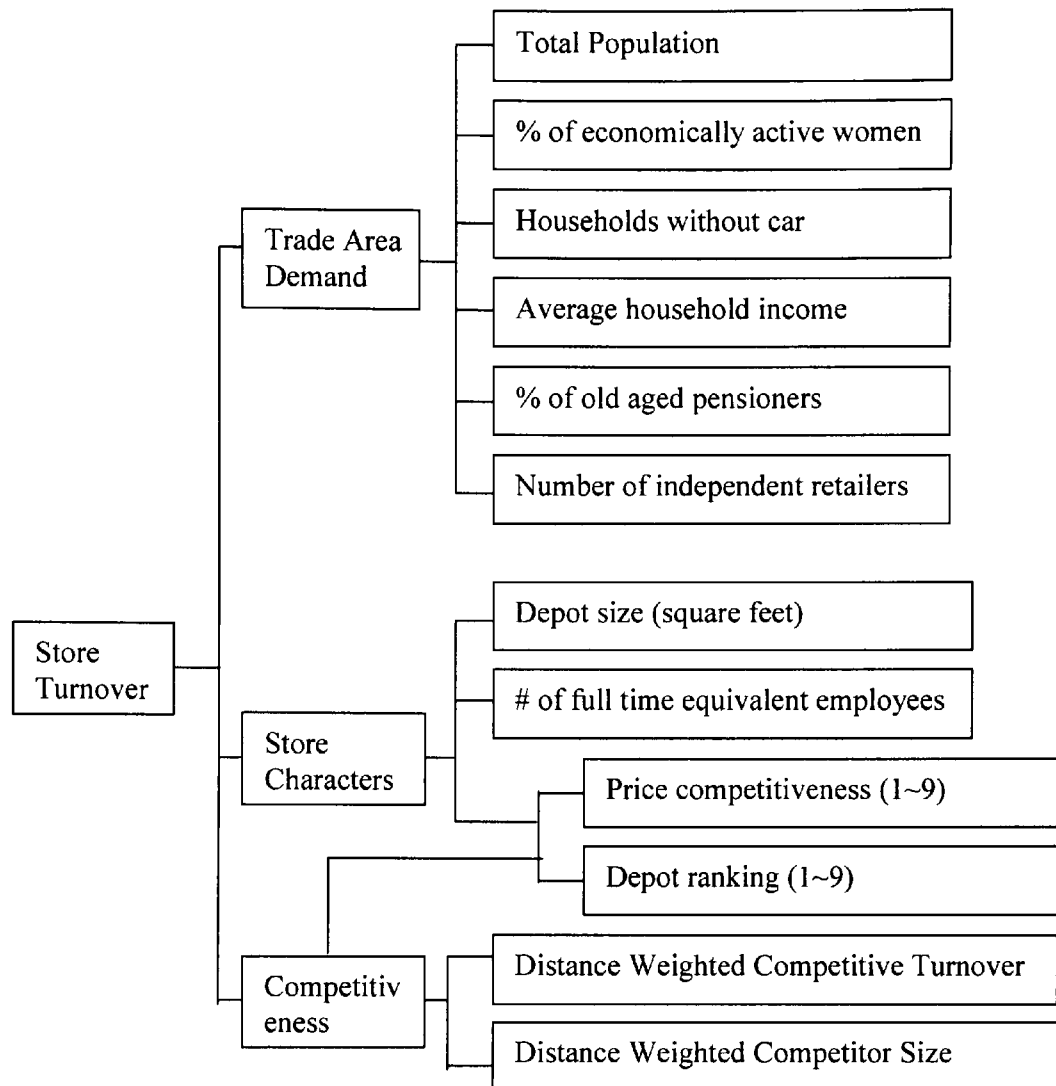


Figure 6.2 Cash and Carry Performance Relationship Structure

The depot RANK and price COMPetitiveness are the internal characteristics, but they also reflect the aspects of competitiveness.

6.3.5 Data Sources

The depot characteristic data provided by the research collaborator, the researched object company, was based on 1991-1993 real data and the experienced managers' expertise. All internal characteristic data of the 459 general Cash & Carry depots in the UK (including 69 members) were collected and stored in the Cash & Carry database.

The demographic data of the 69 trade areas was acquired from a geo-demographic information supplier called CACI. The data was based on 1991 population census.

The trade area composition was also requested from CACI. The file has the following structure:

Half an hour drive time trade area of M 12 4DE

Postal Sector	Drive Time (in minutes)
BL 2 1	28.44
•	•
•	•
•	•
M 1 3	9.26
•	•
•	•
•	•
M 12 5	2.07
•	•
•	•
•	•

From WASP, a marketing information provider, a whole set of independent retailers in the UK (62,279 in total) was acquired. Each retailer's location is indicated by its postal code.

The Institute of Grocery Distribution (IGD) provided a file containing the size and postal code of 2,021 outlets belonging to the top seven multiple superstores.

In order to construct the variables of CUST, DWCT, DWCS and MDWCS, two special computer programs have been designed (The source codes are available in Appendix III). The first program can use the trade area composition and retailer position files to find out the independent retailers in the area. The second one can calculate the variables DWCT, DWCS and MDWCS according to the multiple outlets' size, turnover and the distance to the object depot.

The main data used in this location model analysis is listed in Table A. 5 in Appendix II.

6.4 Regression Analysis

The regression models used are shown as follows:

The linear regression model:

$$\text{TURN} = a_0 + a_1 * \text{SIZE} + a_2 * \text{RANK} + a_3 * \text{COMP} + a_4 * \text{POPU} + a_5 * \text{ACTW} + a_6 * \text{CARL} + a_7 * \text{INCM} + a_8 * \text{OAPS} + a_9 * \text{DWCX}$$

The exponential regression model:

$$\text{TURN} = e^{b_0} * \text{SIZE}^{b_1} * \text{RANK}^{b_2} * \text{COMP}^{b_3} * \text{POPU}^{b_4} * \text{ACTW}^{b_5} * \text{CARL}^{b_6} * \text{INCM}^{b_7} * \text{OAPS}^{b_8} * \text{DWCX}^{b_9}$$

Using the logarithm transfer function: $Y = \text{Log}(x)$, the equation becomes:

$$\begin{aligned} \text{L_TURN} = & c_0 + c_1 * \text{L_SIZE} + c_2 * \text{L_RANK} + c_3 * \text{L_COMP} + c_4 * \text{L_POPU} \\ & + c_5 * \text{L_ACTW} + c_6 * \text{L_CARL} + c_7 * \text{L_INCM} + c_8 * \text{L_OAPS} + c_9 \\ & * \text{L_DWCX} \end{aligned}$$

If the equation is directly transferred from the exponential one, then we have

$$c_i = b_i$$

Where $\text{DWCX} = \text{DWCT}$ or DWCS or MDWCS .

6.4.1 Correlation Analysis

In order to avoid the multicollinearity problem that is caused mainly by the inherent correlated relations between the variables, a correlation analysis is conducted before the regression:

Table 6.4.1 Data Correlation Matrix

	TURN	SIZE	RANK	COMP	POPU	ACTW	CARL	INCM	OAPS	DWCT
SIZE	0.772									
RANK	0.364	0.544								
COMP	0.705	0.669	0.431							
POPU	0.530	0.402	-0.006	0.355						
ACTW	0.332	0.128	0.184	0.145	0.100					
CARL	0.217	0.148	-0.010	0.218	0.369	-0.090				
INCM	0.310	0.017	0.044	0.144	0.237	0.670	-0.393			
OAPS	-0.283	0.007	0.185	-0.131	-0.237	-0.262	-0.054	-0.460		
DWCT	0.611	0.445	-0.009	0.450	0.829	0.156	0.531	0.148	0.144	
DWCS	0.527	0.487	0.014	0.411	0.820	0.023	0.540	-0.043	0.160	0.939

Analysis of the correlation matrix results in the following guidelines:

- There is a strong relation between DWCT and DWCS ($R = 0.939$). In this case, they could only be used in the regression separately.
- There is a weak relation between INCM and CARL. This seems against common sense because normally car ownership would be expected to be higher in the areas where income is high. The reason might be that the percentage of carless households is decided not only by the income level, but also is influenced by the location and the geographic and social structure of the trade area. As these two variables are not significantly correlated, they can enter the regression analysis together.

6.4.2 Pilot Analysis

Because distance weight γ is a non-linear parameter in both models, it has to be configured jointly by the computer automatic procedure and the researchers' judgements. Also, selecting a competitiveness variable among DWCS, DWCT and MDWCS is not a process that can be automatically conducted by a regression analysis. For this purpose, a series of regression results have been produced under different values of γ . The results are shown in Table 6.4.2 through Table 6.4.5

Table 6.4.2 Linear Regression Analysis Result 1

Independent Variables	γ	$R^2 \%$	$R^2(\text{Adj}) \%$	S
SIZE ~ OAPS + DWCT	1.5	69.1	64.5	9.167
+ DWCS		69.3	64.7	9.140
+ DWCT+CUST		69.2	64.0	0.237
+ DWCS+CUST		69.4	64.2	9.211
SIZE ~ OAPS + DWCT	1.0	69.1	64.4	9.176
+ DWCS		69.4	64.8	9.134
+ DWCT+CUST		69.1	63.9	9.245
+ DWCS+CUST		69.4	64.2	9.205
SIZE ~ OAPS + DWCT	0.5	69.0	64.4	9.181
+ DWCS		69.3	64.7	9.142
+ DWCT+CUST		69.1	63.9	9.247
+ DWCS+CUST		69.3	64.1	9.214
SIZE ~ OAPS + DWCT	0.0	69.4	64.8	9.134
+ DWCS		69.1	64.4	9.175
+ DWCT+CUST		69.5	64.4	9.185
+ DWCS+CUST		69.1	63.9	9.246

Table 6.4.3 Exponential Regression Analysis Result 2

Independent Variables	γ	$R^2 \%$	$R^2(\text{Adj}) \%$	S
SIZE ~ OAPS + DWCT	1.5	80.2	77.2	0.377
+ DWCS		80.5	77.5	0.375
+ DWCT+CUST		80.3	77.0	0.379
+ DWCS+CUST		80.7	77.4	0.376
SIZE ~ OAPS + DWCT	1.0	80.2	77.2	0.378
+ DWCS		80.5	77.6	0.374
+ DWCT+CUST		80.3	77.0	0.379
+ DWCS+CUST		80.8	77.5	0.375
SIZE ~ OAPS + DWCT	0.5	80.2	77.3	0.377
+ DWCS		80.5	77.6	0.374
+ DWCT+CUST		80.4	77.1	0.378
+ DWCS+CUST		80.7	77.5	0.375
SIZE ~ OAPS + DWCT	0.0	80.3	77.3	0.377
+ DWCS		80.4	77.5	0.375
+ DWCT+CUST		80.5	77.2	0.377
+ DWCS+CUST		80.7	77.4	0.376

From Table 6.4.2 and Table 6.4.3 the following findings can be concluded:

- There is marginal change of R^2 and $R^2(\text{adj})$ when γ has been adjusted from 0.0 to 1.5. The possible cause is that both DWCS and DWCT do not have a significant contribution

- Between DWCS and DWCT the former is better than the latter because R^2 and $R^2(\text{adj})$ are slightly higher under DWCS.

Based on the above findings, to investigate whether taking multiples as competitors can improve the result, MDWCS is used and compared with the results under DWCS. The results are shown in Table 6.4.4 and Table 6.4.5:

Table 6.4.4 Linear Regression Analysis Result 3

Independent Variables	γ	R^2 %	$R^2(\text{Adj})$ %	S
SIZE ~ OAPS + MDWCS	1.5	70.1	65.6	9.024
+ MDWCS+CUST		70.1	65.1	9.094
SIZE ~ OAPS + MDWCS	1.0	70.7	66.3	8.928
+ MDWCS+CUST		70.8	65.9	8.989
SIZE ~ OAPS + MDWCS	0.5	71.0	66.6	8.886
+ MDWCS+CUST		71.3	66.4	8.916
SIZE ~ OAPS + MDWCS	0.0	70.0	65.5	9.032
+ MDWCS+CUST		70.3	65.3	9.063

Table 6.4.5 Exponential Regression Analysis Result 4

Independent Variables	γ	R^2 %	$R^2(\text{Adj})$ %	S
SIZE ~ OAPS + MDWCS	1.5	80.4	77.4	0.376
+ MDWCS+CUST		80.5	77.2	0.377
SIZE ~ OAPS + MDWCS	1.0	80.4	77.4	0.375
+ MDWCS+CUST		80.6	77.3	0.377
SIZE ~ OAPS + MDWCS	0.5	80.4	77.4	0.376
+ MDWCS+CUST		80.5	77.2	0.377
SIZE ~ OAPS + MDWCS	0.0	80.3	77.4	0.376
+ MDWCS+CUST		80.5	77.2	0.377

A comparison of Table 6.4.2 and Table 6.4.4, which are the results from the linear model, shows that the highest R^2 (adj) (the highlighted cells) has been increased about 2% (from 65% to 67%) by replacing DWCS with MDWCS. This means that MDWCS performed better than DWCS. Though there is no improvement using MDWCS, at least it is not worse than DWCS for the exponential model.

Also it is apparent from the above four tables that adding CUST makes R^2 (adj) drop instead of rise. This means CUST contributes very little to the depot turnover; therefore the further analyses will not use CUST.

For the linear model (Table 6.4.4), the highest R^2 (adj) is achieved at $\gamma = 0.5$. For the exponential model there is not much change under different γ . So the same γ (0.5) can be chosen for both models. This treatment makes the results from the two models easily comparable.

The candidate independent variables chosen from this pilot analysis are SIZE, RANK, COMP, POPU, INCM, ACTW, CARL, OAPS, MDWCS ($\gamma = 0.5$). Altogether nine variables have been identified to be significant enough to be entered into the regression model.

6.4.3 Model Calibration

Linear Model

The best-fit linear model, based on the nine variables, is:

$$\text{TURN} = -19.9 + 0.00169 \cdot \text{SIZE} + 2.39 \cdot \text{COMP} + 0.00013 \cdot \text{POPU} + 1.48 \cdot \text{ACTW} - 1.24 \cdot \text{OAPS} - 0.000034 \cdot \text{MDWCS} \quad (\text{I})$$

For this model, the fitness measurements are:

$$R^2 = 71.5\% \qquad R^2 \text{ (adj)} = 68.6\%$$

P-values of the selected factors are:

<u>Variable</u>	<u>p-value</u>
SIZE	0.000
COMP	0.001
POPU	0.005
ACTW	0.040
OAPS	0.099
MDWCS	0.038

Exponential Model

The best-fit exponential model, based on the nine variables, is:

$$\text{TURN} = e^{-7.83} * \text{SIZE}^{0.590} * \text{COMP}^{0.762} * \text{ACTW}^{1.68} * \text{CARL}^{0.502} * \text{OAPS}^{1.50}$$

(II)

For this model, the fitness measurements are:

$$R^2 = 83.0\% \qquad R^2 (\text{adj}) = 80.3\%$$

P-values of the selected factors are:

<u>Variable</u>	<u>p-value</u>
SIZE	0.000
COMP	0.000
ACTW	0.015
CARL	0.011
OAPS	0.005

6.4.4 Residual Analysis

Figure 6.4.1 and Figure 6.4.2 show the Actual and Forecast turnover comparison of Model I and II respectively. To present a clear demonstration, the depots have been sorted by their actual turnovers in ascending sequence. This arrangement makes the actual turnover curve look smooth and the forecast figures float around the actual ones.

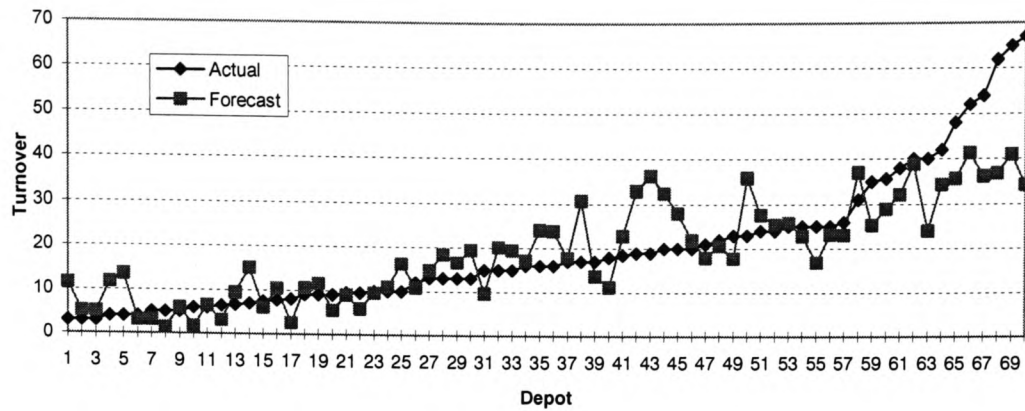


Figure 6.4.1 Actual and Forecast Turnover Comparison under Model I

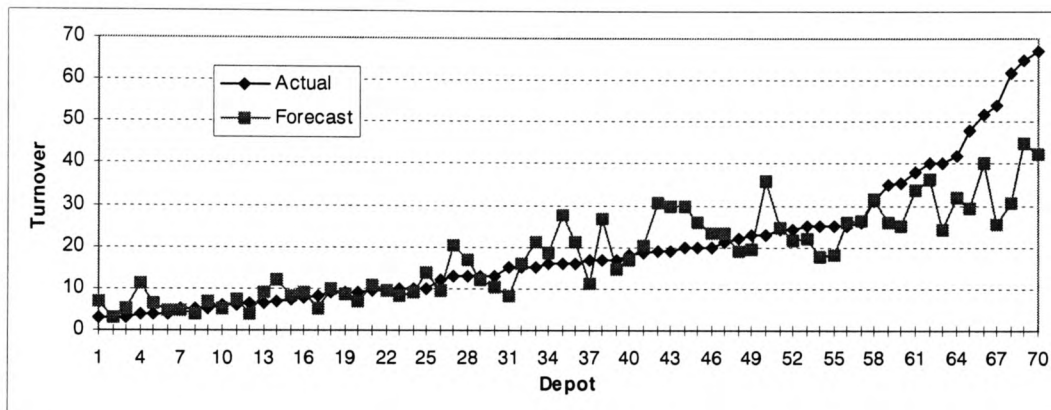


Figure 6.4.2 Actual and Forecast Turnover Comparison under Model II

By comparing the above results from the two models, it is clear that Model II is superior to Model I in two aspects:

- Based on statistics fitness measurements: Both R^2 and R^2 (adj) are higher under Model II. Also, the p-values of the selected factors in Model II are all smaller than 0.0016. This means that the factors are strongly significant in the model.

- Based on the residuals: The forecasts are closer to the actual turnovers in Model II. For example, the prediction of Model I for Depot 43 is 37 million, which is 94.7% higher than the actual turnover. In Model II, it has been improved to 57.9% (prediction: 30 million).
- Both figures showed a trend that the forecast for those depots whose turnovers were 30 million plus deviated from the actual curve. This means that for these depots, there are other factors playing important role. This will be discussed at the end of the section.

To further compare the residual difference between the two models, an indicator, named as % Residual, is constructed:

$$\% \text{Residual} = |\text{Actual} - \text{Forecast}| / \text{Actual} * 100\%$$

This indicator gives a mathematical measurement of the overall residuals.

The results of using the indicator are listed in Table 6.4.6:

Table 6.4.6 Residual Comparison between the Two Models

%Residual	% Depots under Model I	% Depots under Model II
≤ 10	20.0	20.0
≤ 20	37.1	44.3
≤ 30	48.6	57.1
≤ 40	67.1	75.7
≤ 50	74.3	81.4

Table 6.4.6 can be interpreted as this:

- Row1: In both the models, there are 20% depots whose residuals are within the 10% range.
- Row2: In Model I, there are 37.1% depots whose residuals are within the 20% range. Meanwhile under Model II, 44.3% depots achieved the same forecast accuracy.

- Row3 through to Row5 can be interpreted in the same way.

The comparison of %Residual also shows that Model II, the exponential regression model, is better than the linear Model I because Model II has 57.1% depots whose forecasts are within the Actual * (1 ± 30%) range. In Model I, this percentage is only 48.6%.

6.4.5 Further Analysis Using FTE

The reason for not using FTE, the number of Full Time Equivalent employees, in the previous analyses is that there was a difficulty in getting this data. Of the 69 member depots whose data was requested, only 30 depots sent their data back. This data is not a complete set.

But this variable has been recognized as a significant factor by some researchers. It is considered an important variable reflecting service quality, a key factor to the success of a retailer in the highly competitive society. There is the necessity to study FTE's relation with the depot turnover, even though only 30 observations are available.

Exponential Regression Using FTE

The best-fit exponential model, by adding FTE to the nine variables, is:

$$\text{TURN} = e^{6.76} * \text{SIZE}^{0.372} * \text{RANK}^{0.148} \text{COMP}^{0.237} * \text{FTE}^{0.591} * \text{INCM}^{-0.977} * \text{OAPS}^{-0.652} \quad (\text{III})$$

For this model, the fitness measurements are:

$$R^2 = 96.7\% \qquad R^2 (\text{adj}) = 95.7\%$$

P-values of the selected factors are:

<u>Variable</u>	<u>p-value</u>
SIZE	0.000
RANK	0.050
COMP	0.066
FTE	0.000
INCM	0.015
OAPS	0.107

In this model, FTE plays as a strong predictor. The adjusted R^2 not only increases significantly when compared with Model II, the one without FTE, but also is very close to R^2 . This means that all the factors included in the model are significant. Under this model, with 30 depots' data, R^2 (adj) arrived at an impressive 95.7%. Ninety percent of the 30 depots whose forecasts within the range of Actual * $(1 \pm 30\%)$ (See Table 6.4.7).

Table 6.4.7 Residual Scattering under Model III

<u>%Residual</u>	<u>% Depots under Model III</u>
10	50.0
20	76.7
30	90.0
40	90.0
50	93.3

From Fig. 6.4.3 it can be seen that the forecasts matched well the actual turnovers.

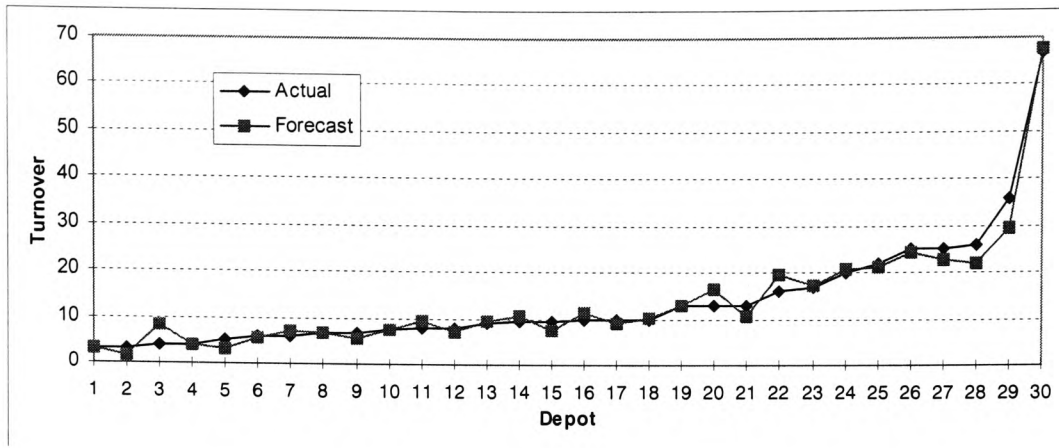


Figure 6.4.3 Actual and Forecast Turnover Comparison under Model III

FTE is an essential factor of Model III. However, in a normal location decision, especially when a new depot is opened, people must face the circumstance of not having FTE data. So both Model II and Model III should be included into the Spatial-DSS. Finally the model (named as MultiRegress) used in the system has been identified as:

$$\begin{aligned}
 & e^{-7.83} * SIZE^{0.590} * COMP^{0.762} * ACTW^{1.68} * CARL^{0.502} * OAPS^{-1.50} \\
 & \quad \text{(without FTE data)} \\
 \text{TURN} = \{ & \\
 & e^{6.76} * SIZE^{0.372} * RANK^{0.148} * COMP^{0.237} * FTE^{0.591} * INCM^{-0.977} * \\
 & \quad OAPS^{-0.652} \\
 & \quad \text{(with FTE data)} \\
 & \quad \quad \quad (IV)
 \end{aligned}$$

Fig 6.4.4 and Table 6.4.8 show the residual scatter pattern under Model IV. By using this model, the percentage of the depots whose forecasts are within $Actual * (1 \pm 30\%)$ range has been increased from 57.1%, the best result without using FTE, to 68.6%.

Table 6.4.8 Residual Scattering under Model IV

%Residual	% Depots under Model IV
10	31.4
20	52.9
30	68.6
40	80.0
50	85.7

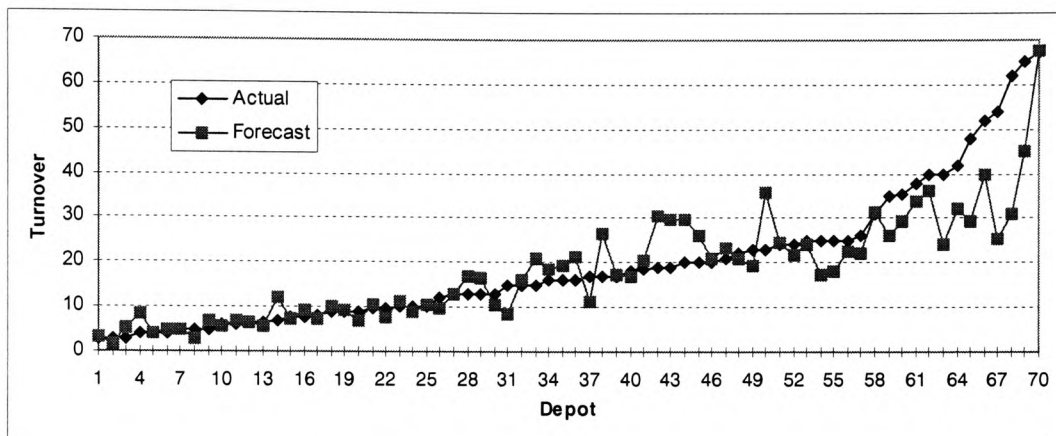


Figure 6.4.4 Actual and Forecast Turnover Comparison under Model IV

Note that in Fig 6.4.4 there is one group of depots whose forecasts are a little farther away from the actual turnovers. The turnover range of this group of depots is 30.0 million plus.

These are the depots whose FTE data was missed in the analysis. Figure 6.4.3 shows that there are only two depots, out of twelve, residing in the range. This indicates that FTE is really very important to the model. There is a necessity for future researchers to obtain this data from more depots.

Chapter 7 Model Validation

7.1 Statistical Analysis

The outputs of MINITAB for Model II and Model III are shown in Table 7.1.1 and Table 7.1.2 respectively.

From the outputs the following conclusions can be found:

- In both models, all the predictors have significant p-values less than 0.10, except OAPS in Model III.
- F-test of the models also expresses a high fitness, with the both the p-values less than 0.001 (see the Analysis of Variance sections of Table 7.1.1 and Table 7.1.2).
- The R^2 and adjusted R^2 , both measuring the degree of explanation of a regression model, are not only high (in Model II both are more than 80%, in Model III both are more than 90%), but also close each other. This means that among all the selected predictors, no one is redundant. On the other hand, for those non-selected variables, no one is significant enough to be able to contribute to model's fit. Actually, dropping any selected factors or adding any un-selected variables causes R^2 (adj) decay a lot.

Table 7.1.1 MINITAB Regression Output under Model II

The regression equation is

$$L_TURN = -7.83 + 0.590 L_SIZE + 0.762 L_COMP + 1.68 L_ACTW + 0.502 L_CARL - 1.50 L_OAPS$$

Predictor	Coef	Stdev	t-ratio	P
Constant	-7.826	3.099	-2.53	0.014
L_SIZE	0.59013	0.07529	7.84	0.000
L_COMP	0.7616	0.1790	4.25	0.000
L_ACTW	1.6793	0.6743	2.49	0.015
L_CARL	0.5015	0.1913	2.62	0.011
L_OAPS	-1.4983	0.5199	-2.88	0.005

s = 0.3253 R-sq = 82.6% R-sq(adj) = 81.2%

Analysis of Variance

SOURCE	DF	SS	MS	F	P
Regression	5	30.6729	6.1346	57.97	0.000
Error	61	6.4551	0.1058		
Total	66	37.1280			

SOURCE	DF	SEQ SS
L_SIZE	1	25.1127
L_COMP	1	2.1008
L_ACTW	1	1.5879
L_CARL	1	0.9928
L_OAPS	1	0.8787

Table 7.1.2 MINITAB Regression Output under Model III

The regression equation is

$$L_TURN = 6.76 + 0.372 L_SIZE + 0.148 L_RANK + 0.237 L_COMP + 0.591 L_FTE - 0.977 L_INCM - 0.652 L_OAPS$$

Predictor	Coef	Stdev	t-ratio	p
Constant	6.762	4.067	1.66	0.112
L_SIZE	0.37235	0.07964	4.68	0.000
L_RANK	0.14814	0.07106	2.08	0.050
L_COMP	0.2373	0.1218	1.95	0.066
L_FTE	0.59052	0.06326	9.34	0.000
L_INCM	-0.9765	0.3688	-2.65	0.015
L_OAPS	-0.6521	0.3860	-1.69	0.107

s = 0.1433 R-sq = 96.7% R-sq(adj) = 95.7%

Analysis of Variance

SOURCE	DF	SS	MS	F	p
Regression	6	11.9399	1.9900	96.85	0.000
Error	20	0.4109	0.0205		
Total	26	12.3509			

SOURCE	DF	SEQ SS
L_SIZE	1	9.0791
L_RANK	1	0.1591
L_COMP	1	0.5940
L_FTE	1	1.9063
L_INCM	1	0.1429
L_OAPS	1	0.0586

7.2 Multicollinearity and Overfitting

Mendenhall *et al*, (1989, pp. 638) pointed out that for a regression with n observations and k independent variables, if the condition:

$$n > 4k$$

was met, then it could avoid overfitting.

In the research,

Model II n = 69 observations,
 k = 5 independent variables,
 n >> 4k has been met.

Model III n=30 observations,
 k = 6 independent variables,
 n > 4k is met.

Both models meet the condition. This supports the conclusion that the models are not overfitted.

7.3 Bias Analysis

By applying the data listed in Table A. 5 (in Appendix II) and comparing the actual and forecast turnovers, it is found:

- 1) For Model II, among 69 forecast figures, 34 were higher than actual ones, 35 were lower. For Model III, among 30 forecast figures, 13 were higher than actual ones, 15 were lower, and 2 forecasts were the same as actual turnovers. Thus both models could be considered as unbiased.
- 2) The forecast turnovers were very close to the actual ones, especially in Model III where the two curves almost coincided with each other.
- 3) Exceptions, i.e., where the actual turnovers were beyond the 95% confidence level, were examined by the company managers and were found to be consistent with the real situation. Hence, the model was suitable to be used in assessing the existing depots' performance. Those depots with turnovers higher than the upper level, can be considered to have performed better than expected. On the other hand, those with the turnovers less than the lower level, were assumed to have performed worse than expected. Further analysis can be done to discover the real reasons for the exceptions.

7.4 Cross-Validation and the Mann-Whitney U Test

Splitting all the data into two sections, one for regression estimation and another for model validation, is an effective way to check the model's correctness.

A commonly used way is to split the sample into halves. However, according to Steckel (1993), a 50/50 split can only produce sub-optimal results. Theoretically, more data in

the estimation sample leads to more efficient estimates, while more in the validation sample leads to a more powerful validity test.

Steckel (1993) compared twelve cross-validated regression studies and found that for very large samples, almost any split provides high power; for moderate samples, one quarter to one third was recommended; for smaller samples, the estimation portion should be higher.

The sample used in this thesis is relatively small. Among total of 69 records, there are four exceptions that are beyond the 95% confidence level and they need to be deleted from the total sample. The remaining 65 observations (actual turnovers and the forecast figures) were split into two sections of 59:6, about 90%:10%. The model was cross-validated by the following two ways:

1) The statistics descriptions of the two sections were shown in Table 7.4.1:

Table 7.4.1 Statistics Description of the Two Sections

	Estimation Section			Validation Section		
	MEAN	STDEV	Correlation	MEAN	STDEV	Correlation
Actual	16.84	11.52		32.20	26.80	
Forecast	16.77	10.49		33.82	13.96	
Correlation			0.871			0.851

From the above table it can be found that the two groups of figures, actual and forecast, were close to each other, both for the estimation and validation sections. In addition, they were highly correlated.

2) Because the Mann-Whitney U-Test can be used to determine whether two independent samples have been drawn from the same population, we used it in our validation and obtained the result (See Table 7.4.2.).

The U Test results show that the two groups of figures, actual and forecast, can not be rejected as coming from two similar samples using a significant level $\alpha = 0.05$.

Table 7.4.2 Mann-Whitney U Test

Table 1 Mann-Whitney Confidence Interval and Test (Estimation Section)

Actual N = 59 Median = 14.000
Forecast N = 59 Median = 13.600
Point estimate for ETA1-ETA2 is -0.200
95.1 pct c.i. for ETA1-ETA2 is (-3.598,3.000)
W = 3478.0
Test of ETA1 = ETA2 vs. ETA1 n.e. ETA2 is significant at
0.8633
The test is significant at 0.8632 (adjusted for ties)

Cannot reject at alpha = 0.05

Table 2 Mann-Whitney Confidence Interval and Test (Validation Section)

Actual N = 6 Median = 19.50
Forecast N = 6 Median = 35.05
Point estimate for ETA1-ETA2 is -9.90
95.5 pct c.i. for ETA1-ETA2 is (-30.32,32.01)
W = 36.0
Test of ETA1 = ETA2 vs. ETA1 n.e. ETA2 is significant at
0.6889

Cannot reject at alpha = 0.05

From the above model's validation analysis it can be concluded that the model is not biased, not overfitted and no multicollinearity has been incurred. It is robust and reliable for Cash and Carry performance evaluation.

7.5 Findings and Discussions about the Results

1. Among all the determinants, depot size is the most significant one. This reveals that the aggregate Cash and Carry location has not come to a 'full structure'. Here, 'full structure' means that larger depot size can not produce higher turnover because of overcrowding. The distribution of Cash & Carry depots is very uneven. In some areas, there is no Cash & Carry competitor in the trade area of the object depot, but in some other places, competition is very intense. There are more than twenty Cash & Carry depots in just a half an hour drive time area. So a macro location structure research about an optimum macro location strategy, which systematically considers the environment factors of area demographics, competition, etc., is very necessary.

2. The Number of Staff should be considered as the second significant factor (although in this research only part of FTE data from the entire member depots have been acquired). It raised adjusted R^2 from 81.2%, among 69 depots, to 95.7% among 30 depots. The later figure might benefit from the smaller sample size; however, it still can be considered as a big jump.
3. The third significant factor is price competitiveness, selected in both models. This reveals, as some other authors pointed out, that 'lower price' or 'good value of money' is one of the most attractive features of Cash and Carry trading.
4. According to 'common knowledge' (or trade expectation), Old Aged Pensioners should be one of the main end consumer groups of Cash & Carry. However, both models reveal that OAPS is negative to turnover. It can be explained that because of the popularity of car use, old aged people prefer to shop in supermarkets for better value-of-money and other advantages, instead in corner shops for their convenience.
5. Another finding that seems to be contrary to 'common knowledge' is that INCM is negatively related to the turnover in Model III. This means that the higher income is, the lower the turnover of the depots located in that area will be. This, after discussion with the managerial experts, can be understood by noting that in the higher income level areas, people often choose to visit supermarkets for better quality and more convenience. Corner shops loose their attractiveness under this situation and this in turn decreases the demands for Cash & Carry.
6. The trade area population, which represents the total end consumers demand, should be an important variable according to the normal retail experience. However, it has not been identified as significant enough to be selected. This result is a little different, compared with some other models developed for the supermarkets or chain stores. However, in the research conducted by Davies (1973), a similar result was also found for the total 72 shops studied.

The reason might be due to the broad covering area of Cash and Carry's customers. Most direct customers visit Cash & Carry depots by car. They can drive from farther away than normal consumers. In addition, from Table 6.3.1 it can be found that

about 30% of C & C business merchandise goes to caterers, pubs, etc. Their consumers usually have more movability, i.e., they come from different areas. Under these situations, the trade area population, a factor representing the trade area consumer demand, becomes weaker in affecting a Cash and Carry depot turnover.

7. In Model III, after FTE is included, all the depot internal factors, in terms of depot size, depot ranking, price competitiveness, full time equivalent number, have been considered as significant predictors. This finding tells us that under the current situation, to improve depot internal management, to provide more convenience, more efficient service and to supply goods with better value-of-money are the key factors in achieving higher turnover.

7.6 Summary

In Chapter 6 and this chapter, a new type of retail trader -- Cash and Carry -- has been discussed and analysed. The relations between the performance of outlets and the internal as well as external factors are studied. Based on the above analysis and research, a conjoint exponential regression model, MultiRegress (Model IV), which can be used under both the situations of FTE, available and unavailable, is developed.

The calibration of MultiRegress does not follow some prior research to 'pour' all the possible variables into their models, as it is based on careful variable selection. Compared with the other location research, one of the unique treatments of this study is that drive time trade area delineation is used. In order to validate the model, a new indicator, % Residual, is introduced, which can give a mathematical sense of residual scattering.

High $R^2(\text{adj})$ of the final model proves that the above techniques are useful improvements to the methods used in retail location.

Although the research was based on a British Cash & Carry group's data, its results, methods and ideas can also be used or transferred to the other Cash and Carry / Warehouse club groups, even to other types of retailers.

MultiRegress has been used by the collaborator company to assess several potential sites. The feedback on the model's results, identified by the chief executive of the company, is "robust and reliable". The model is ready to be integrated into the model module to support the locational enquiry.

Chapter 8 Overview of Spatial Decision Support Systems

The efforts of prior retail location researchers have developed many excellent models. The appearance of GIS has solved the long time problem of spatial data treatment. To put these two different technologies together, in order to form a powerful tool for retailers / wholesalers, requires the knowledge of a new and vivid research area - Spatial Decision Support Systems.

8.1 Development of Decision Support Systems (DSS)

The first concept of DSS was brought up by Gorry and Morton in their paper published in 1971. Since then, this area has developed as one of the key areas of Information Technology and Management Science (MIS).

The result of more than thirty years extensive research leads more and more people to recognize its importance and apply it in different decision circumstances. Eom and Lee revealed, in their DSS Bibliography (1971-1988) (Eom and Lee, 1990), that DSS had been used in almost every branch of social organisations such as Agriculture, Care, Education, Government, Health, Military. In the business fields, DSS was well employed in Accounting / Auditing, Finance, Human Resources Management, International Business, Marketing / Transportation / Logistics, Production and Operational Management, Strategic Management, etc. The application quantity, shown as Fig. 8.1.1, had increased rapidly and steadily. (The drop in year 1988 was caused by the incomplete collection of counts as the authors explained).

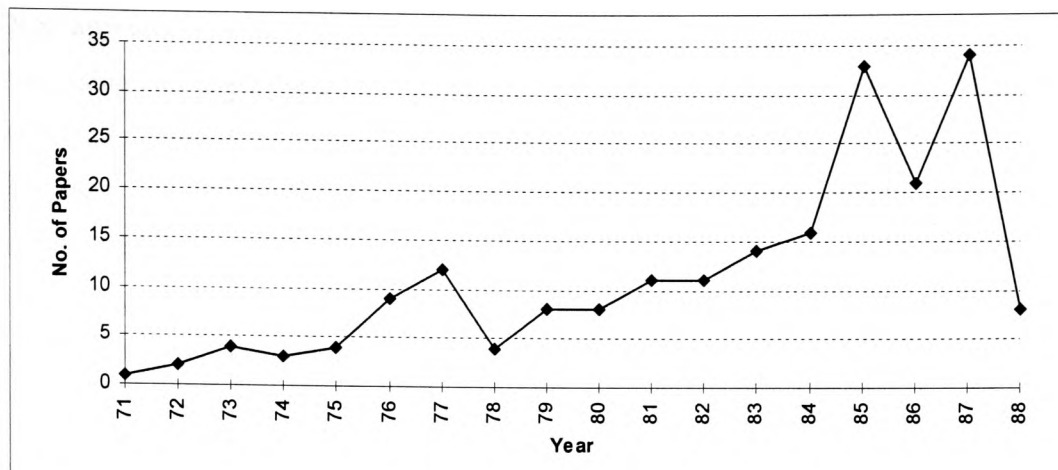


Figure 8.1.1 Annual Count of DSS Applications (1971-1987)

(Source: Eom and Lee, 1990)

DSS is recognized to effectively support decision making. By extending decision makers' cognitive capabilities, DSS can help them to structure decision issues, integrate their judgements with built in problem solving facilities and finally find satisfactory solutions for on going issues.

8.2 Three Levels of IT

DSS has been recognized by most researchers as one of the leading edge tools of modern Information Technology, in the sequence of Electronic Data Process (EDP), Management Information Systems (MIS) and Decision Support System (DSS).

EDP and MIS have been successfully applied to lower operational level and middle management level respectively for a long time, with EDP focusing on transaction processing and MIS tending to provide comprehensive information to meet management needs.

Before DSS, some other systems based on EDP and MIS were developed and used. These systems, in the forms of Office Automation (OA) and Executive Information Systems (EIS), did not characteristically differ from MIS. They were merely considered as different aspects of MIS.

DSS appeared at the intersection of two major evolutionary technologies - Data Processing and Management Science (Sprague, 1987). Data processing grew beginning with data embedded programs, to stand alone data files, databases and currently query languages (known as Structured Query Languages, or SQL). The database management systems (DBMS), especially relational database management systems (RDBMS) and object oriented database management systems (OODBMS), make data maintenance, searching, retrieving and grouping easier and more flexible.

On another dimension, rooted in Management Science research, a variety of decision support models have been built up and embedded into MIS function modules. Finally, they form the basis of a key component of DSS - Model Base (MB).

The significant contribution of DSS, as pointed out by Sprague (1987), was the integration of these two separate trends into a unified whole that creates a synergy effect.

8.3 Definitions and Characteristics of DSS

There are many definitions of DSS. Ginzberg and Stohr (1982) listed the early definitions given by Little (1970), Gorry and Morton (1971), Alter (1980), Bonczek *et al* (1980), Keen (1980), Moore and Chang (1980). These definitions were focused on different considerations of DSS, with respect to problem type, system function, interface characteristics, usage pattern, system objectives, capabilities and components, development process and so on.

Sprague (1980) summarized the two extremes in terms of restricted and broad definitions. The restricted definition of DSS is stated as “interactive computer based systems which help decision makers utilise data and models to solve unstructured problems”. On the other hand, the broad definition, “a system that supports decisions”, considers any system, except transaction processing, as a DSS.

In their nature, decision problems can be classified into three groups. Those problems, which can be fully expressed by mathematical models and whose factors can be quantified, are STRUCTURED problems. On the other hand, the problems which

cannot be quantified and must rely on decision makers' subjective judgements and expertise are called UNSTRUCTURED. Between the two ends are the SEMI-STRUCTURED problems.

In the arguments for accepting either a restricted or a broad definition, people tend to agree that the key concepts of DSS are **interaction, decision support and semi-structured or unstructured decisions**.

Supporting decision-making is the central issue or ultimate goal of DSS. One measurement for assessing the benefits of DSS, suggested by some researchers, should be the improvements of the decision makers' performance with DSS help. Another generally agreed rule is that no matter how intelligent a DSS is, it can only play a 'support' role. DSS should not, and could never, replace decision makers.

Focusing on semi-structured or unstructured decision problems is one of the distinguishing characteristics of DSS from other IT systems. If a decision problem is well structured, then a determined mathematical model package can be used to get a solution directly. There is no need for seeking decision makers' judgements and interventions - thus, no DSS support is needed at all.

'Interactive' can be considered as another specific requirement of DSS. Initially, the decision issue is ill formed because either the issue is not fully understood or it is wrongly understood because of its vagueness. It needs the decision makers to intervene and control all the stages of solution development. With the help of a DSS, decision makers can modify the decision structure, select criteria of the decision factors, assess the output results and probably monitor the implementation of the decision. People now generally agree that the decision makers should be considered as part of a real operating DSS (Ginzberg, 1982).

Ginzberg and Stohr (1982) argued against the term "interactive" and proposed to use "intermittent" instead. The basis for this proposal was that "few decision makers want to have on-line dialogues with their DSS". Their proposal did not conflict with the key point of the concept, i.e., DSS should be run under an interactive, or intermittent, way:

command (decision makers) - information (DSS, computer) - command (decision makers) - information (DSS, computer) - ••• - final solutions.

Rather than defining DSS in several brief sentences to show the difference from definition to definition, some researchers tend to specify the characteristics of DSS. Little (1970) gave six key points a DSS must have. Alter (1980) listed five differences by contrasting DSS with EDP. Moore and Chang (1980) specified four DSS dimensions. Sprague (1980) discussed DSS objectives and capabilities using three “stakeholder” views, in terms of “manager’s view”, “builder’s view” and “toolsmith’s view”. Similarly, Ginzberg and Stohr (1982) grouped DSS characteristics by usage patterns and development patterns.

There have been two kinds of misunderstandings of DSS. One is to take DSS as merely a sort of specific MIS, such as OA or EIS. Another is that DSS can be seen as a totally new era of Information Technology with EDP applied on lower operational level, MIS focused on middle management level and DSS needed at top executive level separately.

The relationship among DSS/MIS/EDP is illustrated by Sprague (1980) as follows:

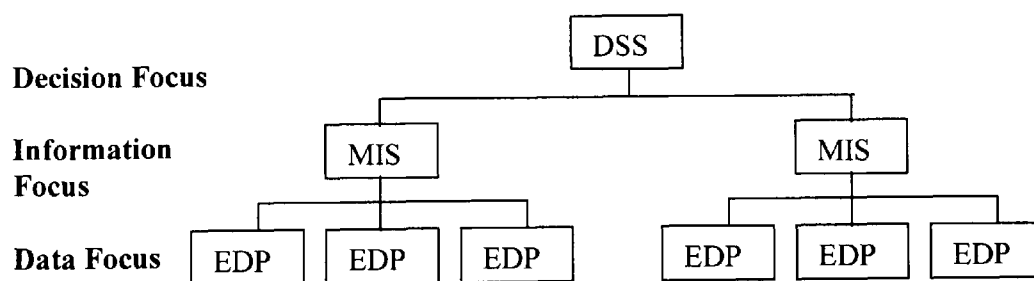


Figure 8.3.1 Relationship of DSS/MIS/EDP

EDP is applied to the lower operational levels of the organization to automate the paperwork. Its basic characteristics include:

- A focus on data, storage, processing and flows at the operational level
- Efficient transaction processing
- Scheduled and optimized computer runs

- Integrated files for related jobs
- Summary reports for management

The MIS focuses on information systems activities, with additional emphasis on integration and planning of the information systems function. The key characteristics include:

- An information focus, aimed at middle managers
- Structured information flow
- An integration of EDP jobs by business function, such as production MIS, marketing MIS, personnel MIS, etc.
- Inquiry and report generation, usually with a database

A DSS is focused higher in the organization with an emphasis on the following characteristics:

- Decision focused, aimed at top managers and executive decision makers
- Emphasis on flexibility, adaptability and quick responses
- User initiated and controlled
- Support for the personal decision making styles of individual managers

To summarize, a DSS can be concluded as follows:

- Decision focusing, support the decision making at all levels of management
- Concentration on solving semi- structured or unstructured problems
- User-friendly data access and model execution abilities, easy to us.
- Flexibility and adaptability to meet the unpredicted changes in the environments and decision making approach
- Human - computer interactive dialogue with efficient two-way communication, controlled by decision makers

Considering the critical comments of the above two misunderstandings, Sprague (1980) pointed out: “DSS is not merely an evolutionary advancement of EDP and MIS, and it

will certainly not replace either. Nor is it merely a type of information system aimed exclusively at top management, where other information systems seem to have failed.”

8.4 DSS Architecture

DSS is one of the most rapidly developing areas in the IT field. Different DSSs have been continually developed to meet the specific requirements. All these DSSs can be identified in three levels:

DSS Tools

DSS tools are the fundamental supporting level for the other two levels. They provide the basic facilities and functions including special purpose languages for system developments; user interfaces to provide convenience for operations; hardware to meet specific requirements.

DSS Generators

The middle level of DSS provides a set of facilities that help DSS designers to build up a specified DSS by tailoring the facilities. DSS generators can speed up the development of DSSs used for different decision-making problems.

Specific DSS

The DSSs at this level are the systems designed for end users.

Specific DSSs differ greatly in their structures. The basic components can be identified using the following model, proposed by Ginzberg and Stohr (1982):

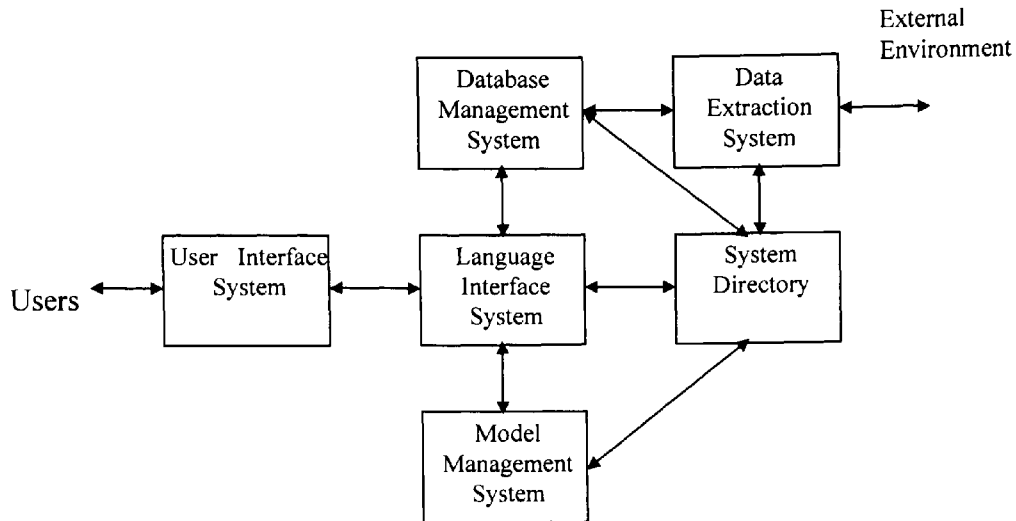


Figure 8.4.1 Major Components of DSS Specified by Ginzberg and Stohr

This is a quite detailed and thorough structure for DSS. Ginzberg and Stohr pointed out that most DSSs only contained some components of their model. It is not necessary for a DSS to have all the components.

Watson and Sprague (1992) illustrated a more concise model for defining DSS structure. They named it the D (Dialogue), D (Data), M (Models) paradigm which can be shown as follows:

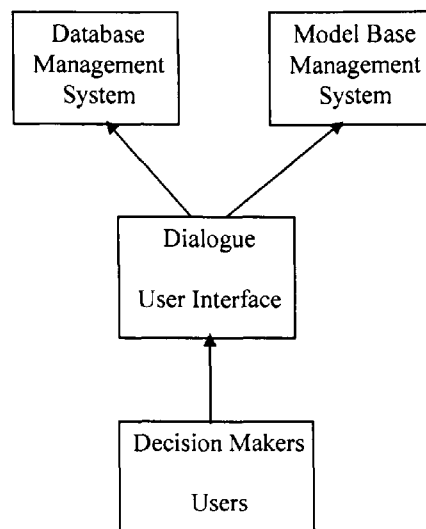


Figure 8.4.2 The Components of DSS defined by Watson and Sprague

The dialogue component, extended from the concept given by Benett (1977), consists of a knowledge base, action language and presentation language. The Dialogue component is also known as the user interface. It gives users accessibility to and controllability of the system and provides the presentation abilities of the results as well.

Data and Model components are not just for data and models; they should also be considered to include their management systems. Database Management Systems (DBMS) is a well-developed and mature area of the IT field. Relational database structure simplifies the operations and such applications dominate the current database market. Artificial Intelligence (AI) has been successfully applied into DBMS and leads to Structured Query Languages (SQL) and Relational Query By Example (RQBE), now commonly available.

By contrast, model base management systems (MBMS) lag far behind DBMS. There are no popularly applied and marketed MBMS packages yet. In theory, MBMS should provide functions to assist the model development, maintenance, auto-search and self-evaluation (mainly supported by sensitivity analyses). The most important capabilities of MBMS should include:

- A flexible mechanism for building models
- Ease of use of the models to obtain needed decision support

- Methods for saving models that will be used again
- Procedures for updating models
- Methods for making output from a model available to other models as input

MBMS research is concentrated in two directions. One trend focuses on applying and extending the relational model for DBMS to MBMS. Another approach is to apply artificial intelligence concepts to model management.

8.5 Spatial-DSS: Development

Spatial Decision Support Systems is a more recent extension of DSS. The concept of Spatial Decision Support Systems was first introduced by Densham and Goodchild (1989,1990). Some authors (Goodchild 1991, Crossland et al 1995, Clarke and Rowley 1995) abbreviated the term into SDSS, inspired by the abbreviation GDSS which stands for Group Decision Support Systems. But SDSS has also been used for Strategic-DSS and Specific-DSS in some other literature. To avoid the confusion, this thesis adopts the term, Spatial-DSS, proposed by Kolli and Evans (1993), as a better representation.

Spatial-DSS can be considered as a special DSS which focuses on providing spatial decision support, mainly location-allocation and distribution / logistics decisions.

Spatial-DSS has only been noticed in recent several years. After the first proposal, Goodchild (1991) commented on the development of GIS and its link with Spatial-DSS. Crossland *et al* (1995) conducted a laboratory experiment with the purpose to investigate the effects on decision-maker performance of using GIS technology as a Spatial-DSS. Clarke & Rowley (1995) and Kolli & Evans (1993) discussed the possibilities of using Spatial-DSS in retail location planning and distribution decisions. Wilson (1994) presented a simple application case of using GIS as a decision support tool for a public district school.

There was some confusion between Spatial-DSS and GIS. Several authors (such as Clarke and Rowley) simply took GIS as a kind of Spatial-DSS.

It is undoubtedly true that GIS has a certain degree of decision support abilities. Some GISs might contain regression and gravity models. Actually, GIS is a kind of specific DSS or DSS tool. It has powerful data management functions and has several models embedded. The current GIS packages have very friendly user interface and dialogue mechanisms. GIS has **Dialogue**, **Database** and **Model** components. It certainly belongs to a DSS with D.D.M. structure as defined by Sprague.

But that is all. People cannot expect GIS to go further. As a GIS producer, to meet the general geographic information enquiry demand is the goal. It is not, and should not be, too focused on supplying specific decision support facilities. This is the work for the other researchers who integrate GIS with DSS to develop Spatial-DSS packages. Both Goodchild (1991) and Kolli and Evans (1993) considered that a Spatial-DSS should be a special DSS based on GIS.

8.6 AHP: Its Role in Spatial-DSS

8.6.1 Review of AHP

AHP (Analytic Hierarchy Process), introduced and developed by Thomas L. Saaty in the 1970's, is an efficient expertise judgement decision method or model. It can combine quantitative and qualitative factors together to calibrate decision makers' subjective judgements. AHP simplifies a complicated decision problem into a concise hierarchy structure. Thus, this method is especially useful for semi-structured or non-structured decisions.

AHP's advantages rely on three principles: hierarchy decomposition, pairwise comparison and synthesis of priorities (Dyer, 1992).

Hierarchy to Simplify the Decision Problems

It is difficult to understand the relationship of the factors in a normal decision without proper models because factors usually entangle each other. Among the models employed in decision-making, hierarchy model is one of the best.

A hierarchy can decompose a decision problem into several levels. The items on each level are homogeneous in relation to one parent item on their upper level. There is no inter-relation among the items on the same level. This kind of structure provides a clear overall view for the relationship of the decision factors and also, because the items are homogeneously related to the upper level, it is easier for the decision makers to make their judgements.

In addition, a hierarchy makes the decision process better structured. With the help of a hierarchy, decision-makers can deal with the factors topic by topic. All the factors can be treated with the same necessary effort. No factors will be missed and no time will be wasted on some unimportant factors.

There are several kinds of hierarchy structures. Forman (1983) provided the following typical examples:

- Goal - Criteria - Alternatives
- Goal - Criteria - Subcriteria - Alternatives
- Goal - Scenarios - Criteria - (Subcriteria) - Alternatives
- Goal - Actors - Criteria - (Subcriteria) - Alternatives
- Goal - ... - Subcriteria - Levels of intensifier (Many Alternatives)

Pairwise Comparison Making the Judgement Most Effective

AHP's other advantage is that no overall weights of the factors need to be given. Instead, the decision-makers are only asked to compare two items each time and give out their judgements of the comparison. The pairwise comparisons then can be

converted or synthesised into weights by calculating the eigenvector of the pairwise comparison matrix.

The calculation procedure can be shown as follows:

Let a_{ij} be the pairwise importance comparison between item i and item j regarding their upper level criterion (parent).

A judgement matrix of the n items of this group can be constructed as:

$$\mathbf{A} = \begin{pmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{pmatrix}$$

In this matrix:

It is obvious that the diagonal elements $a_{11}, a_{22}, \dots, a_{nn}$ are always equal to 1.

$$a_{ii} = 1 \quad i = 1, 2, \dots, n \quad (8.6.1)$$

The upper-right part of elements a_{ij} ($i < j$) are the actual comparisons between item i and item j .

The lower-left part of elements a_{ji} are the reciprocals of a_{ij} , that is:

$$a_{ji} = 1 / a_{ij} \quad i < j, i, j = 1, 2, \dots, n \quad (8.6.2)$$

Suppose the pairwise comparisons are perfectly consistent, that is, the following relation exists:

$$a_{ij} = a_{ik} / a_{kj} \quad i, j, k = 1, 2, \dots, n \quad (8.6.3)$$

According to the matrix theory, for the matrix **A**, which meets all the conditions 8.6.1, 8.6.2 and 8.6.3, there is one, and only one, non-zero eigenvalue $\lambda_{\max} = n$ for the equation:

$$\mathbf{AW} = \lambda \mathbf{W} \quad (8.6.4)$$

Saaty proved that the elements of eigenvector $\mathbf{W} = (w_1, w_2, \dots, w_n)$ are the weights of item 1, item 2, ..., item n.

However, in the real world, the comparisons can not be perfectly consistent. That means condition $a_{ij} = a_{ik} / a_{kj}$ can not be completely met.

Under this instance Saaty proved that if the maximum eigenvalue of Equation 8.6.4:

$$\mathbf{AW} = \lambda_{\max} \mathbf{W} \quad (8.6.5)$$

meets the consistency ratio condition:

$$CR \leq CR_0 \text{ (usually 0.1)} \quad (8.6.6)$$

The eigenvector can still be taken as the weights.

Here,

$$CR = CI / RI \quad (8.6.7)$$

CI is the Consistency Index decided by the maximum eigenvalue and value n, the rank of matrix **A**:

$$CI = (\lambda_{\max} - n) / (n-1) \quad (8.6.8)$$

RI is the random consistency index. RI is calculated by the same equation 8.6.8, but λ_{\max} is under a random matrix A' , with the randomly selected a_{ij} which only meet the conditions:

$$a_{ii} = 1$$

$$a_{ji} = 1/a_{ij}$$

The following table shows the average random consistency index for rank from 1 to 10:

Rank n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

From a purely mathematical view, only $n-1$ comparisons are needed to derive the ratio scale for n items. In AHP, $n(n-1)/2$ independent comparisons (a_{ij}) are used to construct the judgement matrix A . This redundancy, as Dyer (1992) pointed out, “assures that priorities change very little when small changes are made to any one judgement”. The redundancy can smooth some odd comparisons and lead to a compromise being more easily reached when some conflict judgements appear among the decision-makers. The disadvantages caused by this redundancy, in terms of calculation time and data memory size, vanish with the current computer science development.

A 1-9 scale is normally used to measure the importance comparison. This scale, as Saaty pointed out (Saaty, 1990), “has been validated for effectiveness, not only in many applications by a number of people, but also through theoretical comparisons with a large number of other scales”.

Pairwise comparison greatly simplifies the decision makers’ judgements because they only need to concentrate on the comparison between two items, and this is much easier than making a judgement among many items.

AHP’s advantages have been recognized by decision-makers and researchers. Many applications and developments have appeared in different fields of decision making, from government strategy planning to business marketing. Dated to 1992, there were already nearly twenty books and translations into several languages including Chinese,

Japanese, Indonesian, French, German, Portuguese and Russian (Saaty, 1994). Some famous academic journals, such as the European Journal of Operational Research (1990), published special issues particularly devoted to AHP.

AHP was reviewed as one of the successful models for multiple criteria decisions (Ray and Triantaphyllou, 1998). The AHP approach has been adopted in many applications including resource allocation, project selection, auditing, public policy, marketing, procurement, healthcare, corporate planning, transportation planning and so on (Udo and Kirs, 2002).

8.6.2 AHP and GDSS

Based on Simon's three-phased characterization of decision processes, in terms of intelligence, design and choice (Simon, 1960), AHP can be classified as a decision support focusing on the choice phase of decision-making. This is an excellent complement to the other DSS methods / models which focus mainly on the intelligence and design phases. Because AHP can help to make the choice decision among the available options, it is considered as a useful tool of DSS.

Some have argued that AHP, based on its original theory and process, was designed for a single decision maker, and not suitable for a group. Nowadays it is almost impossible that an important decision under complex circumstances can be made by only one person. For the above two reasons, it was questioned whether AHP is suitable in a real DSS, or GDSS area.

This question has already been addressed by a lot of researchers (Saaty 1982, 1989, Bard and Sousk 1990). In addition, Dyer (1992) proposed four directions of integrating AHP into GDSS.

- The simpler way is to use the original AHP model and try to achieve the pairwise judgement by consensus, voting, compromise or geometric mean.
- Consensus is an ideal solution but it is very hard to reach in a group of people. Under this situation, another approach is to vote or make compromise for

some non-consensus judgements. The redundancy of comparison matrix **A** lowers the sensitivity of the priorities. Bearing this fact in mind, if the priorities of these criteria change little when the judgements vary, the group members are more willing to compromise.

- The third direction, the geometric mean method, can be used for those non-compromising judgements. The advantage of using geometric mean over average mean is that it could keep the reciprocal property of the formed judgement matrix **A**.
- If the judgements differ too much to satisfy the participants by simply using the above methods, then it is necessary to amend the AHP hierarchy and make it suit the GDSS environment better. This is the basis of the fourth direction.

A more practical way, proposed by Dyer (1992), is to add a “player” level into the original AHP hierarchy:

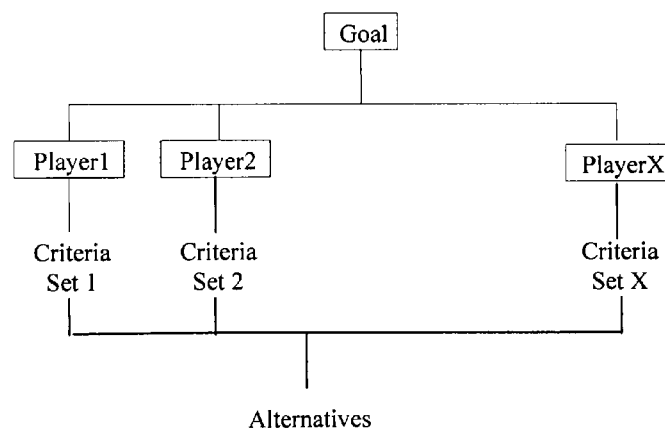


Fig. 8.6.2 AHP Hierarchy with Player Level

In Fig. 8.6.2, the criteria are allowed to be different under each player. As long as the priorities (or importance) of the players is decided, this model can help to make a proper choice decision which combines and balances all players’ judgements.

The difficulty is just how to decide the priority or importance of the players. For solving this problem, Dyer proposed three solutions:

- Players are first assumed to have the same priorities and then the sensitivities under the varied player priorities are analysed. If the player priorities affect the options within a certain tolerant range, the same player priority assumption is acceptable.
- If it is unavoidable to assign different priorities for the different players, a method is to assign the pairwise judgements to the players directly. The player level is treated in the same way as other levels.
- Another method to decide the priority of the players is to construct an assistant AHP hierarchy as shown in Fig. 8.6.3:

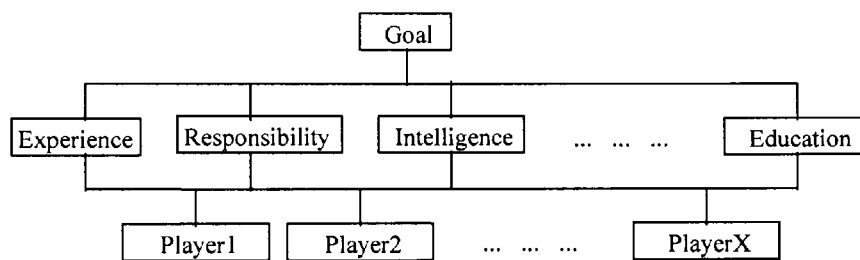


Fig. 8.6.3 A Practical Hierarchy for Deciding Player Priorities

In this model the goal is to decide the priorities of the players. Criteria could be selected from: relative intelligence, years of experience, past work record, depth of knowledge, experience in the related fields, personal involvement in the decision issue, etc. The priorities achieved by this ‘assistant model’ can be applied as the ‘player importance’ in the main model.

Besides Dyer, some other researchers discussed AHP’s application in the GDSS area and the refinements. Saaty (1990) and Harker & Vargas (1990) commented on the use of ‘utility theory’ in AHP applications. Triantaphyllou and Mann (1994) evaluated

several alternative theories and methods and named them as 'revised AHP'. They found that "the revised AHP performed significantly better than the original AHP" (Triantaphyllou and Mann, 1994, p.610).

8.6.3 AHP and Spatial-DSS

There are many methods being applied by retail location planners. The reason for employing AHP in addition to the proposed Spatial-DSS is that none of these methods is optimal. Some of them, such as Analogue and Checklist, are too simplistic to produce satisfactory results for complex decisions. Some methods, like Gravity models, can only produce the results based on one dimension (turnover or market share) and can not make necessary trade-offs among the conflict factors such as profit against cost. Some optimisation models, e.g., integer programming, are very good at helping to make an optimum decision with the systematic considerations of objectives and constraints. However, these models need all the factors to be quantified. This, for most circumstances, is very difficult. Moreover, inadequate quantification will decrease the reality of the models.

Meanwhile, in the previously developed model, MultiRegress, two managerial variables, Price Competitiveness (COMP) and Depot Ranking (RANK), are both identified as the significant factors. These two variables are subjective judgements based on a lot of inter-affected characteristics. To help the managers make proper judgements, there exists the need for a subjective decision model.

AHP is a good method bridging the simplified analogue / checklist methods and sophisticated optimization models. It can combine the subjective judgements and objective data, jointly using both quantitative and qualitative factors to help make trade-off decisions. It is particularly useful for some retail location decisions where there is incomplete knowledge of the target places.

8.6.4 Sensitivity Analysis

Sensitivity analysis is a very important step in decision making. No one can assure that there is no mistake in selecting the method, judging the scenarios or measuring the importance of the factors. Moreover, and probably more importantly, no decision environment is stable. The real world is dynamic. Thus, how do those changes and misjudgements affect the decision results? What is the relative importance of the factors? These are the questions left for sensitivity analysis.

Generally, sensitivity analysis can benefit decision-makers, after a decision has been worked out, in the following aspects:

1. To help the decision-makers understand the inherent relations of the factors in the decision problem - how factors influence each other.
2. To estimate the possible change(s) of the decision results under some demanding factor changes. To allow the decision-makers play What-if scenarios to find out the tolerance ranges of the factors deviating from the estimated value and the necessity of refining the decision process.
3. To persuade people making compromises when they encounter conflicting judgements using the information obtained from the sensitivity analyses.
4. Furthermore, to manage, using the above information, the implementation of decisions and control for sensitive factors, in order to let the development move in the desired direction.

In AHP, sensitivity analysis is mainly focused on the sensitivity of the options, that is, how the priorities of options will change with the importance changes of the upper criteria / sub-criteria level (possibly the players or scenarios levels if they are used). Saaty employed three methods, which are discussed next.

Gradient Sensitivity

Based on the fact that the relations of the option priorities to criteria importance are linear, the sensitivity view of options against the criteria on a selected level can be achieved by the following steps:

1. After finishing the AHP computation, the importance of the criteria on a selected level are w_1, w_2, \dots, w_k and the global weights of options are $Alt_1, Alt_2, \dots, Alt_n$.
2. Select the first criterion and choose two extreme points of its importance, i.e., let $w'_1=0$, then $w''_1=1$.
3. Let the other criteria share the remaining importance with the same ratio as that achieved from the previous AHP computation:

When $w'_1=0$

We have:

$$\begin{aligned}
 w'_2 + w'_3 + \dots + w'_k &= 1 \\
 w'_2 / w'_3 &= w_2 / w_3 \\
 w'_2 / w'_4 &= w_2 / w_4 \\
 &\vdots \\
 w'_2 / w'_k &= w_2 / w_k
 \end{aligned}$$

The solution of the above linear equation w'_2, w'_3, \dots, w'_k is the importance of the criteria at point $w'_1=0$.

4. Run the AHP computation to get the priorities of alternatives $Alt'_1, Alt'_2, \dots, Alt'_n$. These are the priorities of alternatives when the selected criterion has been changed to 0.
5. When $w''_1=1$, we have $w''_2 = w''_3 = \dots = w''_k = 0$.

6. Run the AHP computation again to get $Alt''_1, Alt''_2, \dots, Alt''_n$. These are the priorities of alternatives when the selected criterion has been changed to 1.
7. Let the x-coordinate be the selected criteria importance and the y-coordinate be the priorities of alternatives. We can get n pairs of coordinates: $(0, Alt'_1), (1, Alt''_1); (0, Alt'_2), (1, Alt''_2); \dots; (0, Alt'_n), (1, Alt''_n)$. Link these pairs. The sensitivity of alternative priorities against the selected criterion can be shown as Fig. 8.6.4, which was an example demonstrated by Dyer (1992):

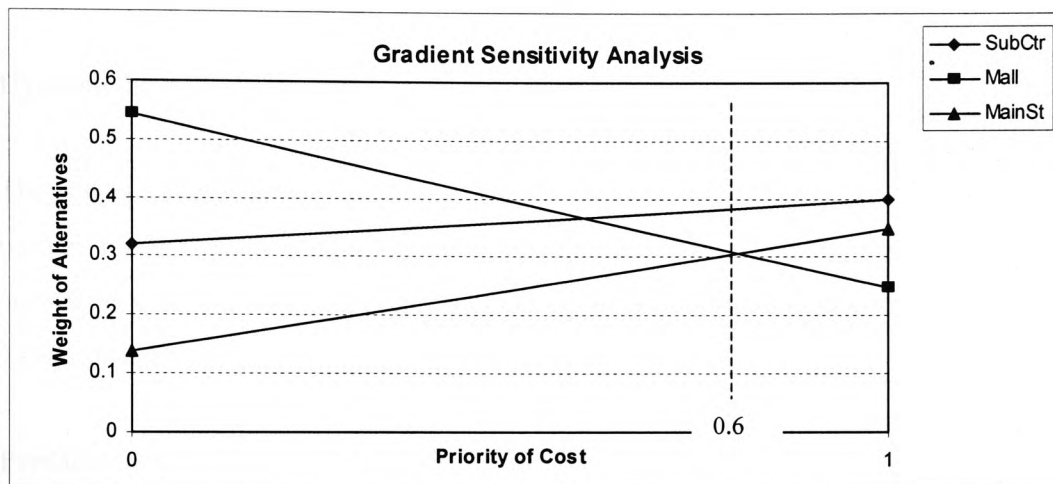


Fig. 8.6.4 Gradient Sensitivity Analysis

8. Change to next criterion and repeat step 2 through to step 7 to get the gradient alternative sensitivity for the new selected criterion.

Figures like Fig. 8.6.4 can give us three clues to sensitivity:

- Which option(s) is more sensitive to the selected criteria. This is represented by the steepness of the lines. In Fig. 8.6.4, the line of “mall” is most steep; therefore, this option is most sensitive to the cost.

- Whether the effect of the selected criterion to options is positive or negative. In Fig. 8.6.4, “Sub Center” and “Main Street” choices are positive to the priority of cost, but the other option, “Mall”, is negative to the cost.
- At which point(s), that is, the priority of cost of the selected criterion being changed to which value, the order of priorities of alternatives will change. In Fig. 8.6.4, when the priority of cost is below 0.6, “Mall” option has the highest weight. When the priority of cost increases for more than 0.6, the highest weight is changed to “Sub Center” option.

Dynamic Sensitivity Analysis

The concept of dynamic sensitivity analysis is the same as gradient analysis as discussed before. Instead of showing a stable graph to view the sensitivity, dynamic analysis allows the user to change the importance of a selected criterion to any value (between 0-1) and then gives out the priorities dynamically.

Performance Sensitivity Analysis

Performance sensitivity analysis is different from the previous two analyses. It uses the local priorities of the alternatives under each criterion on a selected level to view the overall performance of alternative priorities. Fig 8.6.6 is an example:

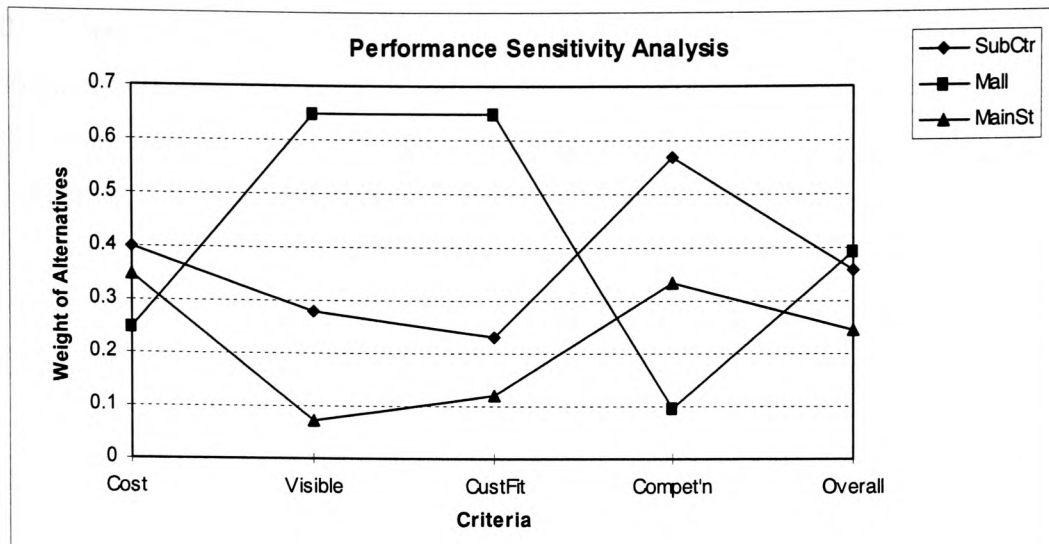


Fig. 8.6.6 Performance Sensitivity Analysis (Source: Dyer, 1992)

In Fig. 8.6.6, the X-Axis shows the criteria on the selected level. Each point represents a criterion. The Y-Axis is the alternative priority.

At each x point, y values are the local alternative priorities. At the last point, Overall, y values are the global alternative priorities.

The local priorities in the figure can help to identify which alternative(s) are more preferred in regards to each criterion. This information, in turn, can help to predict the influence over the alternative(s) by increasing or decreasing the criterion importance. In some cases, performance sensitivity analysis can help to screen off the dominant alternatives (see Dyer, 1992).

8.7 Spatial-DSS: Future Prospect

Retail location has travelled a long route from theory to practice, from simple checklist / analogue methods to complex gravity / regression models and further into location - allocation optimization. With the emergence of GIS, a powerful spatial information analysis tool, retail location reaches the era of using Spatial-DSS technology to enhance

the decision efficiency. Spatial-DSS will be a prosperous research area. It is a new solution to, and certainly will play an important role in, retail location decisions, but at the moment, it is a very new, almost undeveloped, area awaiting and welcoming its cultivator.

The following chapter will focus on the design of a Spatial-DSS for the research company, a British Cash & Carry retailer.

Chapter 9 Design of a Spatial Decision Support System

As pointed out before, Spatial-DSS is a very new frontier of the DSS area. There is little published literature dealing with practical Spatial-DSS systems. The initial purpose of this chapter is to describe a design for a Spatial-DSS, LmSDSS, for the studied British Cash & Carry company. The key source codes of the system are listed in Appendix III (The whole system consists of over 10,000 lines of source codes).

9.1 Database Module Design

A database has always been a fundamental component for most decision systems. Without a properly designed database with its management system, decisions would be mere imagination.

The main function of a database module is to meet the requirements of data maintenance and information enquiries as well as the data preparation for the various models in Spatial-DSS. Based on the prior retail location research, in order to meet the retail location management requirements, the following data elements have been selected:

Store Characteristics

The table stores the internal characteristics information for all concerned stores in the target areas. The “concerned stores” means the object store with its member outlets (if it is a multiple chain retailer), the customer (for retailers such as wholesalers) and the competitors. There is no necessity to store all the businesses in the country.

The fields or the characteristics selected to be stored should include:

<u>Name:</u>	The name of each outlet.
<u>Category:</u>	The category the outlet belongs to.
	For example:

M ---- Member outlet
C ---- Customer
P ---- Competitor

Address: Outlet address.

City: The city where the outlet is located.

Province (or County / State): The Province/County/State where the outlet is located.

PostCode: The postal code or ZIP code of the outlet location. Postal code must be separated from the address because most GIS systems take it as the spatial data location unit.

Telephone: Main contact telephone(s) of the outlet.

Performance: Measurements of the outlet performance, such as turnover.

Outlet Scale: Variables selected can be outlet size (gross size or front sales area size), number of employees, number of checkouts, etc.

Outlet Rank: The subjective rank regarding to the loyalty of customers, competitiveness of competitors, etc. Sometimes the subjective judgements can play a very helpful role in assessing retail performance.

Car Park Availability: It is an important factor affecting the willingness of consumers/customers to visit the site because most shopping trips are car based.

Petrol Station at the Site: It again, for the same reason as above, affects the consumers/customers' willingness to visit the site.

Most of the above data is available from the business information provider. For example, WASP, a provider in the UK, can provide basic business information such as name, address, telephone, postal code, etc., and the sales volume and employee size.

For the information not publicly available, such as Outlet Rank, conducting a mail survey or telephone interviewing will help to collect the data.

National Demographics

The Census survey is the most reliable and official source of consumer spatial information. Normally a completed census database contains several hundreds to over a thousand demographic counts. Not all the counts are necessary and related to retail location management. The following variables are tailored from the census database and selected into the consumer demographics database of the system:

- Population counts
 - ◆ Total population
 - ◆ Population Segmentation by Age and Sex. In the census, the population is usually segmented at five-year intervals and further divided into male and female. Thus, the variables selected in this section are:
 - Male00~04, Male05~09, • • •, Male95up;
 - Female00~04, Female05~09, • • •, Female95up.
- Employment Status. Variable selected are:
 - ◆ Employed Male
 - ◆ Employed Female
- Household related count variables selected are:
 - ◆ Total households
 - ◆ Family with children
 - ◆ Dwelling type
 - Owner
 - Renter
 - ◆ Average dwelling value
- Car Ownership. Variables selected are:

- ♦ Number of Households with 0 Car
 - ♦ Number of Households with 1 Car
 - ♦ Number of Households with 2 or More Cars
- Average Household Income.

All the demographic data should be at the census basic unit level (ED/OA/ EA) and have the following geographic variables attached:

- ED/OA/ EA ID
- Latitude: The latitude of the ED/OA/ EA centre
- Longitude: The longitude of the ED/OA/ EA centre
- City: The city to where current ED/OA/ EA belongs
- Province/County: Where current ED/OA/ EA belongs

In GIS, the position of an object is represented by a pair of co-ordinates: latitude and longitude. They are also called the geocodes of the object.

Consumer Demographic Information

This proposed Spatial-DSS is able to define the trade areas and extract the consumer information (or demographics) dynamically from any place in the country based on the National Demographics database.

For most routine management, only the information relating to location management is needed. A long wait is needed to extract the data from a national demographic database each time of enquiry. Based on this consideration, the database module should also have a brief consumer information database in the defined trade areas. Normal enquiries will be based on this smaller database instead of the huge national one. The database consists of the following fields: (The reason for selecting these variables have been discussed in previous chapters.)

<u>Location:</u>	The centroid location of each trade area. It is expressed by postal code.
<u>Population:</u>	The total population in the trade area.
<u>Income:</u>	Average household income in the trade area.
<u>% Active Women:</u>	Percentage of economically active women (women with jobs).
<u>% Carless Households:</u>	Percentage of the households without a car.
<u>% OAPs:</u>	Percentage of Old Aged Pensioners.

Geocoding

Postal code is a commonly used basic position unit (such as the location of competitors or customers). In order to display an object (a business outlet) on a map, it must be assigned with a pair of X and Y co-ordinates by matching its location with a standard geography database that resides in the GIS. This process is called geocoding. A nation-wide postal code database with the geocode for each postal code is designed into the GIS module.

<u>Postal Code:</u>	Each record contains a unique postal code in the country
<u>Latitude:</u>	The latitude of the postal code centre (Urban postal codes are very small, and therefore, they can be taken as a point. However, the rural postal codes are much bigger. The centre of the postal code must be used).
<u>Longitude:</u>	The longitude of the postal code centre

ED/OA/ EA – Postal Code Converter

As explained before, the Census and the Post Office use two different geographic systems. To match the consumer information published by the Census to a business outlet with postal address, the system must have the ability to convert the census location to its postal location or vice versa. Hence, following data must be available:

Postal code

ED/OA/ EA

Latitude

Longitude

Each record in this database represents the relation between the postal code and the ED/OA/ EA. In the case when the postal codes and ED/OA/ EA overlap each other, multiple records must be created. As a result, the number of records will be more than the total number of postal codes available in the country.

Road Structure and Road Speed Statistics

Road structure and road speed statistics is an optional database when drive time is concerned. In the UK, the roads with speed statistics available are motorways, A Roads and B Roads. In Canada such data is grouped into primary roads, secondary roads and streets. The geocodes and speeds of each part of these roads are stored in the database. With this database, GIS can show the roads on a map and calculate the drive time between any two points.

In summary, the data needed in the system can be briefly illustrated by the following figure:

Store Characteristics	National Demographics	Consumer Information	Postal Geocode	PC – EA/ED Converter
Name Address Telephone City Province PostCode SalesArea GrossArea Checkout Scanning CarPark PetrolStat	Related Census Counts	Postal code Population Income % Active Women % Carless House % OAPS	Postal code Latitude Longitude	Postal code EA/ED Latitude Longitude

Figure 9.1.2 SDSS Database Structure

9.2 Model Base Design

By contrast to the intensive development of the database, the model base management system is still under development. This is due to the fact that models are more complicated objects than data to manage and need more expert knowledge. (Liu, 2000).

Many modern computer languages, such as FoxPro, have very friendly user interfaces. The Windows style event driven programming abilities and data / command exchange facilities mean that they can be used to develop a model base management facility which can search and drive the designated model(s) under the users' control or to follow the embedded researching rules. This design idea was initially proposed by Ginberg and Stohr (1982, p. 16).

In the system, a carefully calibrated multiple regression model (MultiRegress, See Chapter 6 for detail) is by default built into the model base to provide site assessing for the research object company (with multiple stores at different locations).

The real application environment is always changing. To meet this kind of challenge, one of the characteristics a DSS should have is the “flexibility and adaptability to meet the unpredicted changes in the environments and decision making approach” (see

Chapter 8). Providing a model reasoning mechanism that can help to calibrate new model(s) is an important feature of decision support systems.

For this reason, a regression modelling mechanism is designed into the model base. It can dynamically calibrate a new best-fit model under the built in rules and procedures. Regression modelling uses a statistics package, MINITAB, as the regression-computing tool. The next section provides the design details.

With the above model components, the model base of the system can provide the following functions:

Depot Performance Analysis

The model base supports users to develop “what-if” scenarios between depot turnover and the significant factors. Users can pick up any Cash & Carry depot and change some factors to see the influence of these possible changes to the turnover (based on the configured regression model; the default is MultiRegress).

Depot Assessment

The model base compares the forecast and actual turnovers of the researched company’s member depots to assess which depots performed better than expected, which did worse and which were within the confidence levels.

The assessment is based on the regression results and 95% confidence level. It uses the turnover forecast model to forecast the turnover for all the selected depots and then compares them with the actual turnovers. Both the forecast and actual turnovers together with the 95% confidence levels are shown by a dot graph. The forecast turnover(s) will be shown in red if it exceeds the confidence levels.

The assessment is based on the configured regression model. The default is MultiRegress.

Turnover Prediction

It utilizes the calibrated location model to predict a proposed depot's expected turnover with the designated internal characteristics and location of the site (consumer information will be automatically picked up by the location).

Regression Modelling

A Windows styled object-driven facility supports users to calibrate the multiple regression models with the input data. The model can be used to replace the built in location model MultiRegress or for the other usage (See next section for design details).

The modelling module can also be used to configure trade areas. The delimitation of the trade area is important to the results of retail location analyses. The size of a store's trade area depends on various factors such as the store's attractiveness, the merchandise category (daily consumed goods or durable furniture, etc.), population density, traffic infrastructure and so on.

A feasible way is to run the regression analyses by dynamically linking it to a Geographic Information System. With the census data, road structure and competitor characteristics databases, a GIS is able to provide the spatial consumer structure and competitiveness distribution data for any area. Having this advantage, the regression model can analyse the data formed on different sizes of trade area to find out a best-fit.

The model base of the system can be illustrated by following figure:

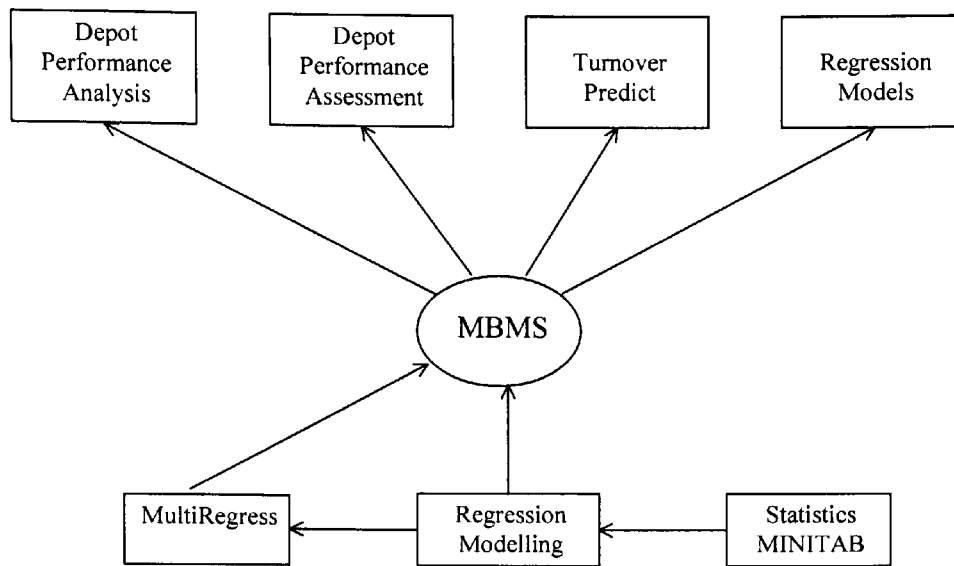


Fig. 9.2.1 Structure of Model Base Module

9.3 GIS Module

9.3.1 Functionality Design

The following mapping functions are designed to support retail location management.

Trade Area Delineation

Users are able to configure a trade area by any one of three ways: drive time, distance radius and polygon drawn manually.

- **By Drive Time:** Users can point out a centroid and a time length (e.g., 30 minutes). GIS will draw the area on the map and export the postal code with the drive time to a data file.
- **By Distance Radius:** Users still need to point out a centroid but enter a distance (e.g., 25 miles) instead of a time length. GIS will draw a circle area on the map and export the postal codes with the distance to a data file.

- By Manually Drawing a Polygon: Users can draw a polygon with any pattern. GIS will show the defined area on the map with the postal codes.

Spatial Information Enquiry

The system can display the spatial information within any defined area. The area can be chosen from:

- A trade area configured by any of the above methods
- A standard enumeration area, such as a postal sector or a town

The spatial information can be selected from the variables:

- Consumer demographics
- Member outlets (position and internal characteristics)
- Customer information (position)
- Competitor information (position and internal characteristics)

The last three options are available by linking the respective databases designed in the DATABASE module introduced before and the geocode postal code database.

Trade Area Overlap Analysis

The trade areas of stores often overlap each other. Consumers in these overlapped areas are more likely to switch from one store to another. Analysing the features of these consumers can help to make specific promotion measures to attract these people and this, in turn, to expand the store's territory.

For the above purpose, this function is designed to help users obtain a visual sense of the overlapped area. It can show the overlapped area, by a shadowed pattern, between any two trade areas. Users can click the area to get the spatial information relating to the area.

This function can also help to de-overlap the area, i.e., to assign each unit in the area to only one trade area. There are several ways to do this. The most common and easy way is to assign the unit to its nearest trade area.

Figure 9.3.2 is an example of an overlapped area between two trade areas.



Figure 9.3.2 An Example of Trade Area Overlapping

9.3.2 GPS and Drive Time

As stated before, drive time is another commonly used measurement. It is also recognized as a better measurement than the physical distance because it can reflect the real time customers spend on the trip to the store and this affects the willingness for them to choose a target store.

Drive time can be collected by different methods. A simple method is to use the speed limit applied to the roads. The speed limit normally is the same for all the roads in one class.

But this method cannot take the factors, such as the traffic flow and the number of intersections, into consideration. Actually because of these factors, speeds will differ significantly for the same class roads.

To include the statistics of speeds on individual roads will result in more accurate measurement. This information can be bought from some organizations such as AA in the UK.

If this kind of data is not available or too expensive to produce, then a third method, using GPS (Global Position Sensor), becomes useful.

Overview of GPS

GPS refers to the Global Positioning System, a constellation of 24 satellites that orbit the Earth twice a day at an altitude of about 12,000 miles. These satellites continuously broadcast high-frequency radio signals containing position and time data. This function enables anyone with a GPS receiver to determine their location anywhere on Earth. The GPS signals are available to an unlimited number of users simultaneously.

Every point on Earth can be identified by two sets of numbers, referred to as coordinates, which represent the exact spot where a horizontal line (latitude) crosses a vertical line (longitude). GPS receivers report and record the position of the object with a pair of latitude/longitude coordinates. GPS receivers also produce other critical navigation information. The most useful forms of information are: heading, moving speed, date, time and so on.

The basis of GPS technology is precise time and position information. Using atomic clocks (accurate to within one second every 70,000 years) and location data, each satellite continuously broadcasts the time and its position. A GPS receiver uses signals from three or more satellites at once to determine the user's position on earth.

By measuring the time interval between the transmission and the reception of a satellite signal, the GPS receiver calculates the distance between the user and each satellite. Using the distance measurements of at least three satellites in an algorithm computation,

the GPS receiver arrives at an accurate position fix. Information must be received from three satellites in order to obtain two-dimensional (latitude and longitude) fixes, and four satellites are required for three-dimensional (latitude, longitude and altitude) positioning. The position information in a GPS receiver may be displayed as longitude/latitude, Universal Transverse Mercator, Military Grid or other system coordinates.

The U.S. Department of Defense began development of the \$12 billion GPS satellite navigation system in the 1970s to provide continuous, worldwide positioning and navigation data to U.S. military forces around the globe. However, GPS has even broader civilian applications. Position and navigation information is vital for many professional and personal activities, including boating, surveying, aviation, vehicle tracking and navigation, and more.

To meet these different needs, there were previously two levels of GPS services, one for civilian access and the second encrypted for exclusive military use. The civilian GPS signals were subjected to Selective Availability (SA) interference by the United States Government. This meant that there were random errors in the data transmitted by the satellites to reduce the civilian GPS signal accuracy to 100 metres. However, on May 1, 2000, the U.S. government removed SA from GPS signals. The result was a times greater accuracy for public users of GPS – position fixes that are usually within 10 metres.

Users can further increase the overall accuracy of GPS receivers with correction signals from technology called differential GPS (DGPS) or from satellite systems, such as the Wide Area Augmentation System (WAAS), developed by the United States government; the European Geostationary Navigation Overlay System (EGNOS); or Asia's forthcoming Multifunctional Transport Satellite-based Augmentation System (MSAS).

WAAS, EGNOS and MSAS satellites calculate errors in the GPS signal; then the satellites transmit correction messages to WAAS-capable GPS receivers. The result is a position reading that is as accurate as three meters or better. With DGPS, users gain real-time accuracy within the 10-meter range when one GPS receiver unit is placed at a

known location and the position information from that receiver is used to calculate corrections in the position data transmitted by the satellites. This corrected, more accurate information is then transmitted to other GPS receivers in the area. Users can also obtain sub-meter accuracy by using DGPS and post-processing calculations in static positioning.

GPS Applications

GPS becomes popular in business applications when the price of the device drops and some satellites open to the public. Following are some typical applications:

- Navigation: GPS is able to provide the exact location on the earth. This function can help to locate vehicles, aircrafts and vessels or other objects. The users then know where they are and can quickly find the best route to the target. On the other hand GPS is also used to track objects with GPS devices installed. This function is especially useful for fleet management and object monitoring.
- Surveying: Many larger cities are now using GPS and GIS to manage their infrastructure. Vehicles and highways are integrated in a coherent information network that facilitates the travel of individual vehicles to optimise traffic flow and increasing traffic capacity throughout the entire road system
- Mapping: Using GPS can easily define certain borders. For example, helicopters equipped with GPS can fly the perimeter of a forest and create a map of the burning area.
- Monitoring: GPS is used to evaluate the routing of vehicles and set off alarms if vehicle moves were not authorized.
- Safety: GPS in cell phones will allow location software to bring authorities to an emergency.

Some other applications:

- Real estate evaluation and taxation assessment
- Atmosphere and air quality studies
- Environmental protection
- Demographic and marketing analysis
- Resource and scientific exploration
- Advertisement board/poster reach frequency estimation

To use this method in drive time statistics, first, a certain quantity of GPS receivers (depends on the empirical trade area size, the time limit of the project and the budget) should be acquired. Second, a sample of consumers who drive in the empirical trade area must be selected. Then each consumer in the sample is approached to ask for permission to put the GPS into his/her car.

If this kind of field survey is too time consuming and expensive, an alternative way is to send someone to drive around the trade area. On average, a week should be enough to finish a survey one trade area approximately half an hour drive time.

For a period of time (e.g., a week), the GPS will record the route travelled by the consumer. The route is composed of individual points normally at 100 meter intervals. (This default interval is adjustable). Following is a typical output of the GPS receiver:

```
>REV001154251878□□1139992602319612;ID=8829;*56<
>REV001154251887□□1139993303018012;ID=8829;*59<
>REV001154251895□□1139993102818012;ID=8829;*5C<
>REV001154251919□□1139994100719512;ID=8829;*5A<
>REV001154251938□□1140009102226312;ID=8829;*52<
>REV001154251947□□1140024202626212;ID=8829;*55<
>REV001154251956□□1140039803025612;ID=8829;*51<
>REV001154251964□□1140054002924012;ID=8829;*50<
>REV001154251972□□1140065903222312;ID=8829;*5C<
>REV001154251979□□1140071603119212;ID=8829;*5A<
```

The output contains the following key data:

- Latitude
- Longitude
- Altitude
- Time when the point is created

9.4 Regression Modelling

In Chapter 6, much effort was put into calibrating and integrating a fixed retail location model for the Cash and Carry / Warehouse Club sector, but real environments always keep changing. The data set employed in the analyses will soon be out of date and replaced by a new one. Therefore, the location models, no matter how carefully they are calibrated, might not fit the new data. They need to be re-calibrated under the new data set.

Further, as pointed out before, a pre-fixed trade area cannot meet the requirement of the real world. Different types of businesses have different sizes of trade areas. There is not a well-accepted trade area configuration method yet. Combining managerial expertise to delineate the trade area, the method used before, is one of the alternatives people have to use when a spatial data processing tool is not available. An ideal solution, proposed in Chapter 3, is to choose a best delineation by comparing the results from different sizes of trade areas. This method needs a lot of data processing that is too time consuming to be conducted by manual analyses.

On the other hand, the calibration procedures of the retail location model using the regression method can be easily standardized. Analysts normally select a model type, then select variables, analyse the significance of the variables to decide which should be chosen as the factors in the model and finally validate the model's reliability. Most of the tasks can be automatically fulfilled by computerized procedures.

So a retail location modelling mechanism, which has the automatic model calibrating ability is not only necessary to retail location planning, but also feasible when integrated with a Geographic Information System (GIS). The following sections demonstrate the methods and steps employed in the development of a modelling subsystem.

9.4.1 Method

When conducting a regression analysis, the first thing for analysts to do is to select a model type. In the retail location area, two types of regression models are popularly

used. They are the linear and exponential models (See comments in Chapter 6). Both the models should be available in the modelling mechanism.

Secondly, the analyst must decide the dependent variable. In retail location, it is normally the store performance, which is normally selected from the variables such as store turnover, net (gross) profit, etc.

Thirdly, the independent variables that possibly affect the store performance are selected. From previous research, many such variables have been identified. These variables can be grouped into three categories: store internal characteristics, external competitiveness and spatial consumer information. Data for the first two groups are usually collected by the users (analysts or the company). Data in the third group are available in a GIS with census databases.

With manual calibration a trade area size must be decided in order to collect the data from the areas after the variables have been selected. Here the module's modelling mechanism searches for the best trade area, based on the results.

The variables often have non-linear relations with store performance. Most non-linear relations can be turned into linear by applying certain types of transfer functions:

$$X' = f(X)$$

Suppose there exists a model:

$$Y = a_0 + a_1 X_1 + a_2 X_2^2$$

Substitute: $X' = X^2$

The model becomes:

$$Y = a_0 + a_1 X_1 + a_2 X_2'$$

The new variables X_1, X_2' now have linear relations with Y .

The common transfer functions are:

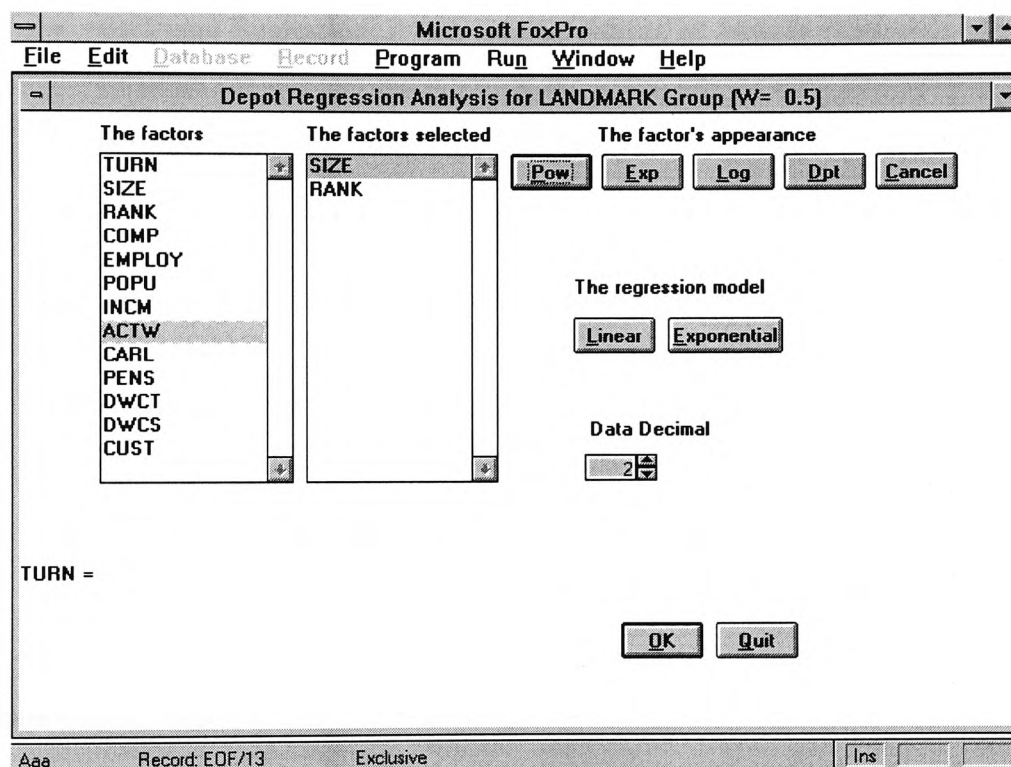
Exponential: $X' = e^x$

Logarithmic: $X' = \text{Log}(X)$

Power: $X' = X^n$

When $n = 1$, power relations become linear relations.

The screen for entering the above model configuration details is shown in Figure 9.2.1:



9.4.1 Screen of Regression Modelling

9.4.2 Model Reasoning: Steps and Measures

There are three model calibration methods in regression analysis:

- Stepwise Regression: At each step only one variable that will have the most contribution to the model among un-selected variables is added, or one that has the least contribution among the selected variables is dropped. Most statistics packages have this function and can automatically calibrate the “best” model under this method.
- Forward Regression: It is similar to stepwise regression except it does not drop variables. The model is empty at the beginning. At each step it selects one or more variables into the model, according to their contribution, normally judged by the p-values.
- Backward Regression: It is a reverse process of forward regression. All the variables are put into the model at the beginning. At each step, drop one or several variables according to their contribution, normally judged by the p-values.

All these three methods are employed by the reasoning module. The reasoning rules are:

Objective:	1) Maximise R^2 (adj) 2) Minimise $R^2 - R^2$ (adj)
Subject to:	p-value $X_i \leq 0.10$ (p-value of each selected variable is less than or equal to 0.10) p-value $Y \leq 0.05$ (p-value of calibrated model, F test, is less than or equal to 0.05)

These rules are adjustable in the “Reasoning Rule Management” function.

The execution of model reasoning can be achieved using AUTOMATIC or INTERACTIVE ways. When AUTOMATIC execution is selected, the module will run the reasoning by itself based on the built in rules. A final result is produced at the end. The results at each step, i.e., any time when adding more variables or dropping variables or switching the calibration methods from stepwise to forward to backward, are recorded into a result file with ASCII format.

If users want to control the modelling procedure, they can select INTERACTIVE execution. Under this method, the module will pause upon finishing each step. The results will be presented on the screen (or printed out upon request). Users can choose to either let the system proceed to the next designed step, or force the system to a step selected by the user (e.g., subjectively add or drop several variables which might not comply with the defined rules). Using this design, users have the power to control model reasoning at two levels: to adjust the rules before the reasoning, or to intervene in the reasoning execution.

MINITAB is selected as the internal statistics tool. MINITAB is a command driven package with the ability to read / write fix length ASCII files. The commands can be entered in either single or batch method. For the latter method, the commands can be pre-edited into an ASCII file and then executed, just as the normal programs do. The LmSDSS regression modelling is based on this ability.

Call Command Execution

The main commands for executing regression analysis are:

READ FROM <data file> C ₁ -C _x ;	Read data from the named file into column array C ₁ through to C _x . x is the number of the last variable.
OUTFILE <result file> ;	Name a file to store the regression output results.
REGRESS C ₁ C ₂ - C _x ;	Run the regression analysis. C ₁ is always taken as the dependent variable. C ₂ - C _x are the independent variables.
NOOUTFILE ;	Close the result file and turn off OUTFILE status.

The regression results will appear on the screen or can be stored in the file if an OUTFILE command has been issued.

The data file and result file are fixed to LM_DATA.TXT and LM_RGSS.LIS separately. Among the above commands, the only parameter in change is C_x, which relates to the variable selected. The commands are put into a file called LM_RGS.MTB.

In the modelling module there is a procedure which can automatically change C_x in LM_RGS.MTB to cope with variable selection.

After LM_RGS.MTB is built up, issuing RUN MINITAB LM_RGS.MTB can execute the required regression analysis without leaving the system.

Export Data

The database management system (FoxPro) can directly export data into SDF (Standard Fixed length ASCII) format file, which is suitable for MINITAB, by using the command COPY TO <file> SDF.

Extract Model Information from Regression Results

This is a different set of processes within LmSDSS. The MINITAB regression outcome contains a lot of information, such as model coefficients, fitness, T-test and F-test results. All the information is put into a plain ASCII file. It is easy to read visually but difficult to extract by computer.

After careful analysing of the output file format, the MINITAB regression output file is seen to have the following features:

- The model information is on the line beginning with " $C_1 =$ ";
- The variable significance information is contained on the lines starting with "Constant" and finishing at a blank line;
- The model fitness information is on the line beginning with " $s =$ ".

The regression model can be constructed by substituting C_i with the real variable names. The fitness information is held on a single line. The module just needs to read it and show it on the appropriate screens so that users can assess the current model.

Variable significance information is somewhat complex. Each variable occupies one line with five columns. The p-values, which are needed for model assessment, are stored at the extreme right column with fixed 5 digits. Thus the p-values can be extracted by reading the line and trimming from the right side to 5 digits.

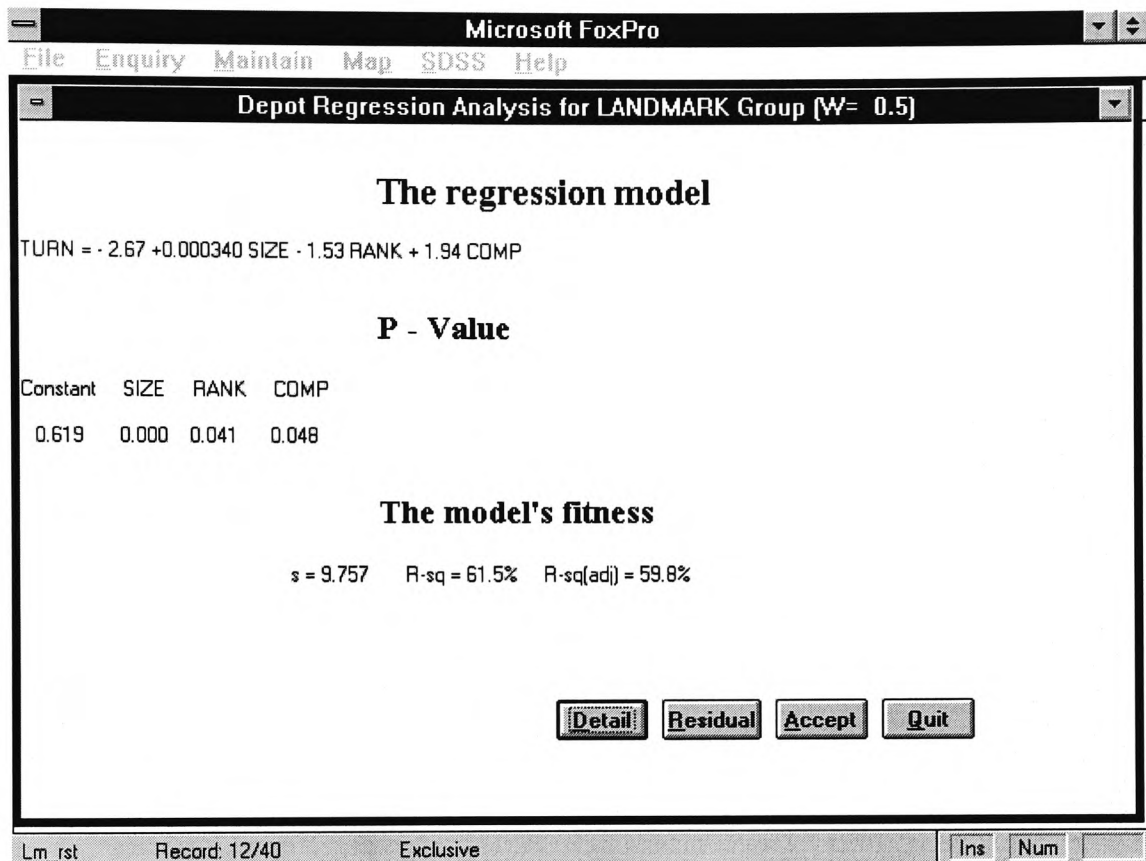


Figure 9.4.2 Regression Result

9.4.4 Results Presentation

The results at each step, including the final result, are stored in a database. The details selected to be stored are:

- 1) Step number: Presents a sequence numerical number to identify each step;
- 2) Step manoeuvre: Indicates what kind of reasoning manoeuvre was applied at this step. The manoeuvres are:

- Adding variable(s)
 - Dropping variable(s)
 - Switching calibration methods
- 3) Regression outputs: Contains information such as R^2 , R^2 (adj), Analysis of Variance, Model Coefficients. The format is the same as Table 6.8.1 in Chapter 6. It is stored in a memo field.
- 4) Residual plot: Shows a visual depiction of residual scattering. The format is the same as Fig. 6.7.1 or Fig. 6.7.2. The graph is stored in a general field (a specific field type used to store pictures).
- 5) % Residual distribution: The residual indicator introduced in Chapter 6. This information, which has the same presentation format as Table 6.7.7, is also stored in a memo field.

Figures 9.4.3 ~ 9.4.6 are the result presentation screens designed for the system:

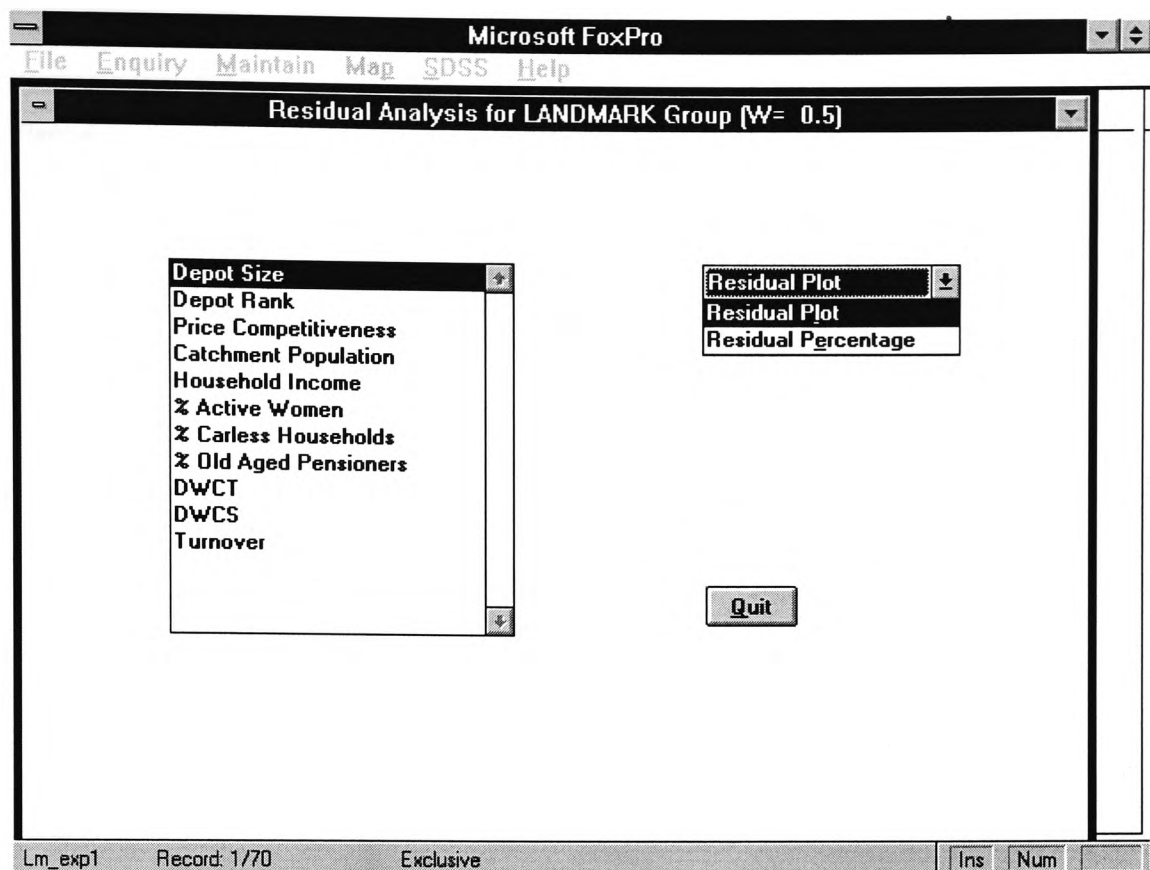


Figure 9.4.4 Residual Analysis

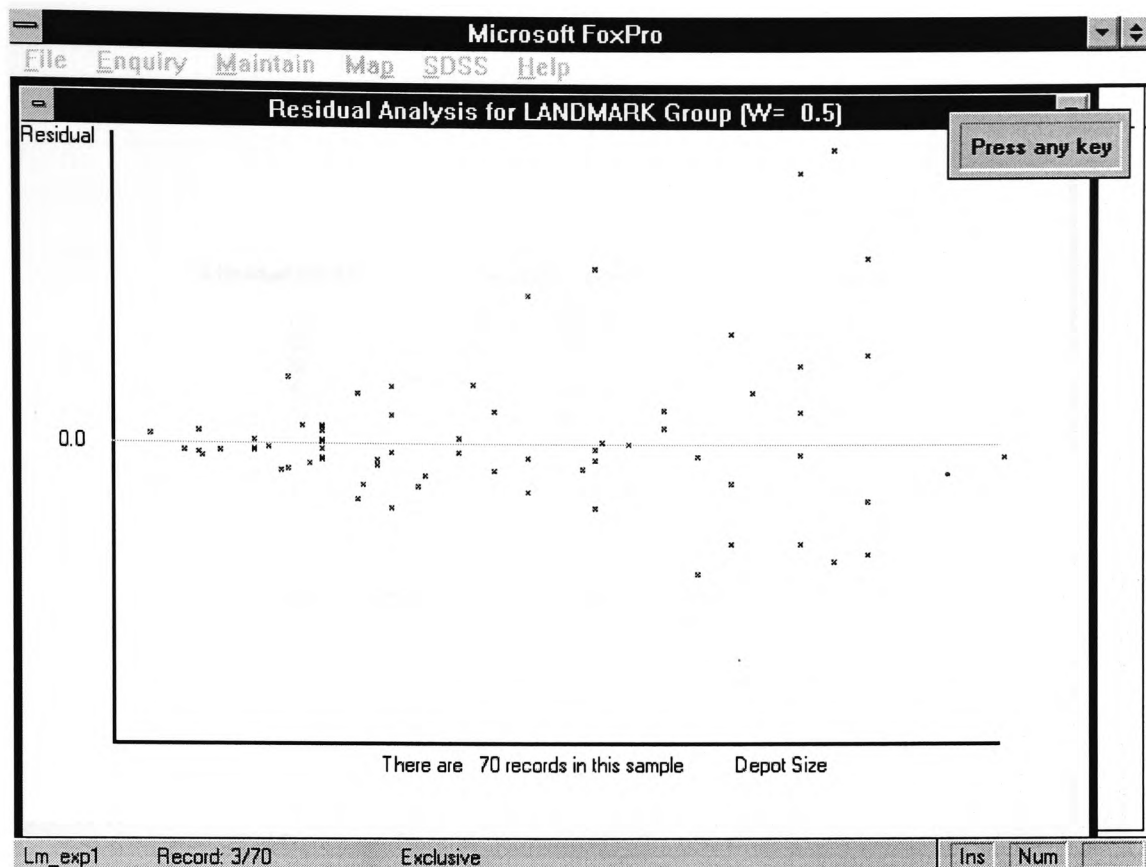


Figure 9.4.5 Residual Plot

In the above figure, the residuals are in absolute value. Depots with higher turnovers (at the right hand) normally have larger forecast residuals.

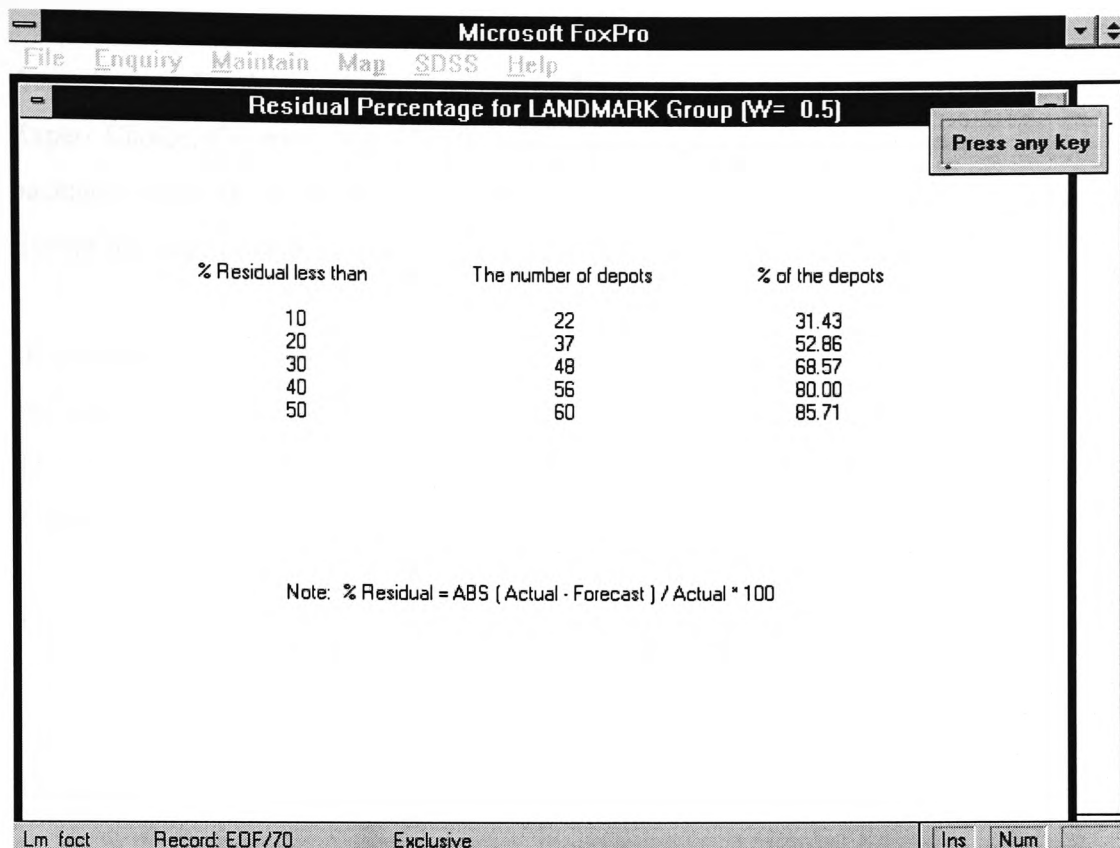


Figure 9.4.6 Residual Percentage

9.5 AHP Module

Although calculation simplicity is one of AHP's advantages, a computer program is still necessary. The reasons are:

- For large judgement models, there are still too many calculations.
- AHP should be operated in a dynamic way: dropping out the less important elements and adding in new important ones, according to the results. A quick response is important.
- AHP is most suitable for senior decision makers and it is unwise to expect them to master the mathematics of AHP.

According to Buede's review in 1992, there were three commercial AHP packages, Expert Choice, Criterium and HIPRE, being developed to meet decision needs. These packages were all operated under the traditional DOS computer operation system. Except for these three packages, no other AHP packages were available at that time.

Obviously, it is not desirable to use DOS version packages now because the Windows operation system prevails in the personal computer world. Because of this consideration, the author programmed the Windows version AHP package, AHPforWN, and integrated it into Spatial-DSS.

AHPforWN Design

Cash and Carry is a special trade sector in retail business. Many previous researchers discussed the variables influencing performance, or simply the turnover, of a retail outlet. In the Regression Analysis chapter, the independent variables related to a Cash & Carry depot in particular were analysed. Based on the fact that the highest turnover is one of the most important goals for a satisfactory depot location, these variables plus the operation costs and some other environment concerns, form the base of Cash & Carry location decision variables.

Using the theory of AHP, these factors are decomposed into the following Goal-criteria-subcriteria-alternatives hierarchy (The hierarchy is presented by AHPforWin Screen 2 in Chapter 9):

Top node of the hierarchy is the goal, which is to evaluate a best location.

Under the goal is the criteria level of the hierarchy, consisting of six criteria. Each of the six criteria contained several sub-criteria. The six criteria are:

Demographics

There are five sub-criteria under this criterion:

- Trade area population
- Average household income
- Percentage of Economically active women
- Percentage of carless households (This factor might be important to Cash & Carry)
- Percentage of old aged pensioners

Competitiveness

- Same business competitors (General Cash & Carry)
- Other competitors (e.g., the multiples and specialist Cash & Carry)
- Strongest competitors (Some competitors are so strong that it is very difficult to compete with them nearby)

Attractiveness

- Independent retailers: they are the main customers of Cash & Carry; measured by the total number or sum of the size / turnover.
- Caterers: they are also the customers of Cash & Carry; same measure can be applied as above.
- Complement stores: these stores can attract more multi-purpose shoppers, including some small shop owners.
- Leisure facilities: these can also attract more people to visit the store.

Distribution

The decision-maker must consider the distribution relation of the proposed site with the existing outlets. There are two sub-criteria under it:

- Distances from the proposed sites to the existing outlets
- Influence of the new outlet over the old ones

Accessibility

The accessibility to main roads, such as a motorway, A road or B road (in the UK) or Primary road, Secondary road and street (in Canada).

Investment

The total cost of opening a new outlet.

The bottom level of the hierarchy represents the alternatives, i.e., the proposed sites.

In this hierarchy, a clustering method is employed to group sixteen factors that influence the location decision into six homogeneous subsets with no more than five factors in each set. This arrangement is to ease the difficulty in making the comparison because psychology research has long shown that people might only be able to judge properly among a limit set of 7 ± 2 items / factors (Miller, 1956).

AHPforWN Outputs

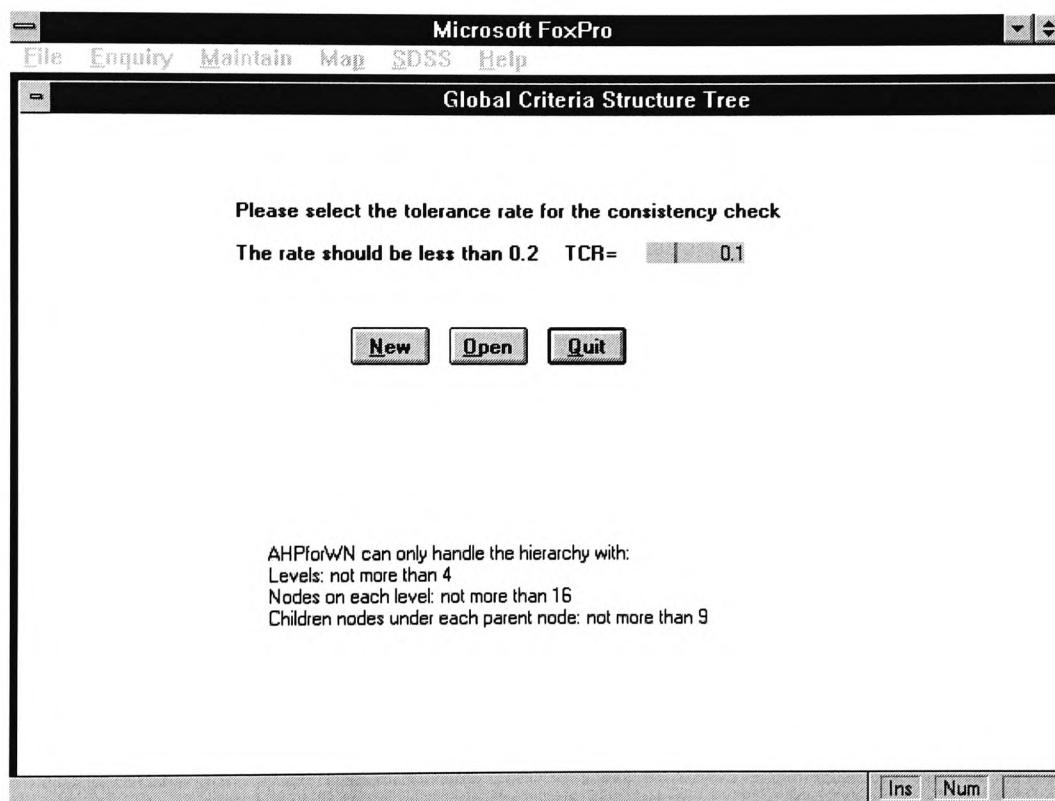
AHPforWN can provide the following functions:

- Helps to build up a new hierarchy or modify an existing one. For Cash & Carry / Warehouse Club site selection, users can use the built in hierarchies.
- Synthesises the comparison judgement matrices A_i into local and global weights.
- Checks the local and global consistencies of the matrices. If any consistency rate exceeds the determined limit, a warning message will be given. The default limit is set to 0.1. Users can change the default setting at the entrance to the package.

- Allows three kinds of sensitivity analyses, in terms of Gradient, Dynamic and Performance, in AHPforWN.
- Provides Online help facilities.
- Displays user friendly interface. The user only needs to use the mouse to click on the desired buttons to manipulate the whole operation.

AHPforWN has four screens:

Screen 1: Package Entrance



Using this screen, users can choose to create a new data file that can store the new decision hierarchy or to open an existing hierarchy file.

If users choose to create a new file, the file structure will be copied from a standard file. On the other hand, if an existing file is chosen, AHPforWN will check its structure to

see whether it is an AHP data file. If the structure is different from the standard, a warning will be given.

Users can enter the tolerance level of Consistency Rate (CR). Normally CR should be kept to less than 0.1 (the default value), but users are allowed to choose a higher value.

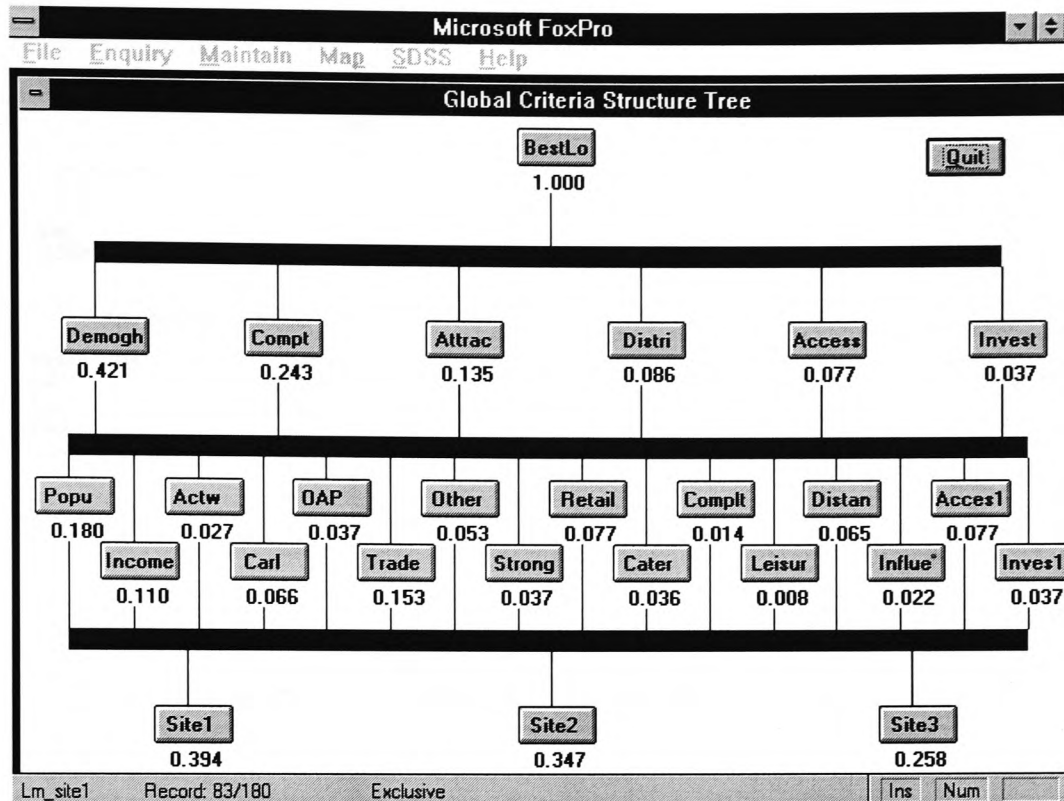
The limits of the levels and the nodes on each level are determined by screen size.

Acceptance:

There are two choices: <OK> for accepting the selected parameters and execute the exporting, <QUIT> for cancelling all the selections and return to the upper level calling menu.

Hot Key: Press <Enter> for <OK>, <Esc> for <QUIT>.

Screen 2: Global Hierarchy



This screen displays the global structure of the selected decision hierarchy.

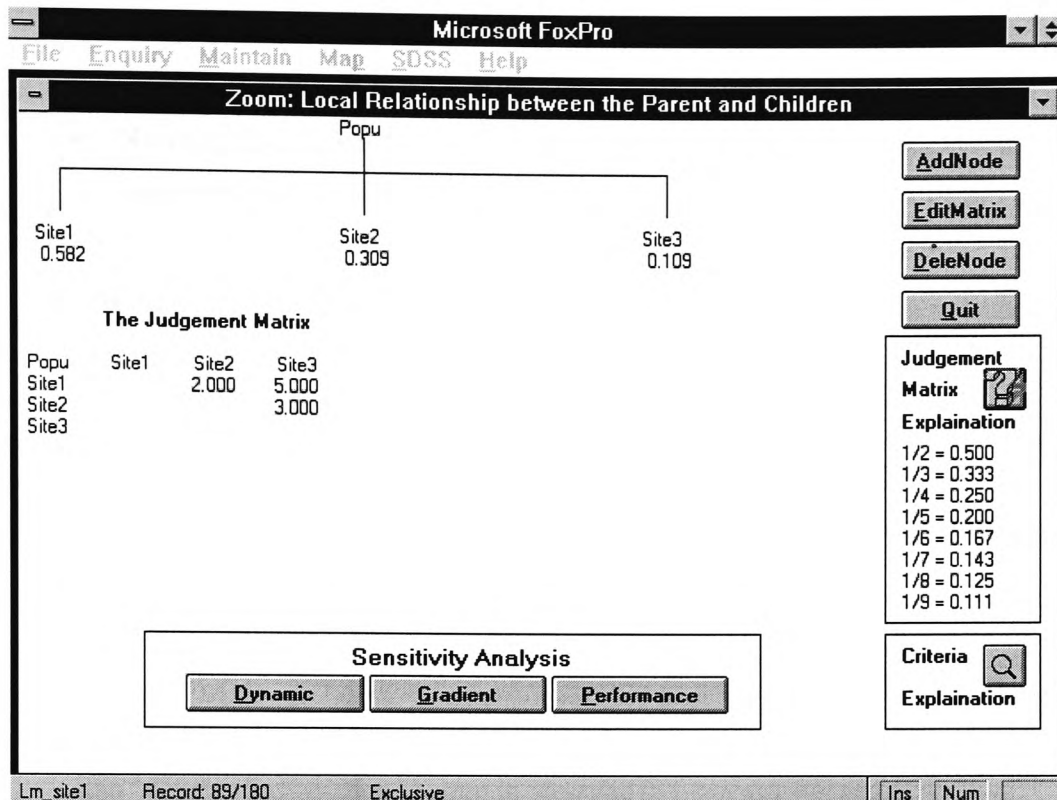
The hierarchy is shown by levels. On each level, the nodes are represented by push buttons. Each node name consists of up to six characters. The figure under a node is its global weight.

From this screen, the detailed relationship between the parent node and its children is not visible. Users can click any node to zoom into the Local Tree screen.

Clicking <QUIT> returns to the calling menu.

Hot Key: <Esc> for <QUIT>.

Screen 3: Local Tree



This screen provides a local tree view of the node, which has been clicked, with its child nodes, and the AHP operations.

The screen is divided into five parts.

1. In the top-left corner is a figure that shows the relationship between the parent and children nodes.
2. Under the local tree figure is a matrix that holds the pairwise comparisons inputted by the user.
3. In the bottom-left corner is a push button consisting of three SENSITIVITY ANALYSIS choices:

- Gradient and Performance analyses need Microsoft Excel as the base of their graphs. Users cannot view the results of these two analyses without Excel being open.
 - Nevertheless, Dynamic Sensitivity Analysis is available at any time when users click this button.
4. At the right, there are two help buttons that can be selected to obtain necessary information.

If users click the "Judgement Matrix Explanation" button, a popup window appears, which presents a text explanation of the recommended judgement scores 1-9.

Though it only allows the use of six characters to name a node, AHPforWN gives users an access to enter the full explanation for the node. Users can click the "Criteria Explanation" button to view the full explanation and make any change.

5. At the top-right corner there are several buttons executing the main AHP operations:

- AddNode: Add a new child node under the current parent.

When this button is clicked, a list that contains all the available nodes' names on the children level and a confirmation button will replace the right part controls.

Users can enter the new name directly or choose from the list. If a new child node name is entered, it is advised to enter the explanation of the node at the bottom (though users can enter/change the explanation using the "Criteria Explanation" button described above). If users select a name from the list, the explanation will be shown automatically at the bottom.

Upon users clicking on the <OK> button, the node will be added into the current local tree. Clicking on <CANCEL> will abandon the AddNode operation.

- EditMatrix: Edit the pairwise comparison matrix.

When this button is clicked, the matrix will be highlighted and a confirmation button will replace the operation buttons.

Users can edit the elements, i.e., enter or change the pairwise comparisons. The new values will replace the old ones if users click the <OK> button. Clicking <CANCEL> can abandon all the edited values and restore the original ones.

If users click on the OK button, which means the new comparisons being entered, AHPforWN will recalculate the local and global weights and check the Consistency Rate of the comparison matrix. If CR is greater than the given tolerance range, a warning will be given. Users then need to adjust the elements.

- DeleNode: Delete an existing child node.

When this node is clicked the relationship lines between the parent and the child nodes disappear. The child nodes change to push buttons with the same name. A QUIT button will replace the operation buttons.

Users can click any child node button to delete it. A confirmation window will appear. If <OK> is clicked, the node will be deleted from the hierarchy. Clicking the <CANCEL> can avoid the wrong operation.

Clicking on the <QUIT> button can terminate from DeleNode operation.

- Quit: Quit from the Local Tree screen and return to Global Hierarchy.

Hot Key: <Esc> for <QUIT>.

Screen 4: Dynamic Sensitivity Analysis

Microsoft FoxPro

File Enquiry Maintain Map SDSS Help

AHP Dynamic Sensitivity Analysis

Selected Criterion: **Popu**

Change the weight to

Popu	0.120	Site1	0.381
Income	0.118	Site2	0.350
Actw	0.029	Site3	0.269
Carl	0.071		
QAP	0.040		
Trade	0.164		
Other	0.057		
Strong	0.040		
Retail	0.083		
Cater	0.039		
Complt	0.015		
Leisur	0.009		
Distan	0.070		
Influe	0.024		
Acces1	0.083		
Inves1	0.040		

Lm_site1 Record: 46/180 Exclusive Ins Num

In this screen, users can change the weight of a selected node to any value by using the spinner. When users click the <OK> button, AHPforWN will execute the dynamic sensitivity analysis and show the new weights of the other nodes on the same level of the selected one, and the alternatives. This result demonstrates the degree of sensitivity for the selected node.

Clicking on the <Quit> returns to the Local Tree screen.

Chapter 10 Conclusion

10.1 Summary of the Thesis

Throughout the previous chapters, a popular decision area - Retail Location - has been thoroughly reviewed. The theories, methods, models and tools employed in this area have been discussed and compared. In particular, a special business sector – Cash and Carry / Warehouse Club – has been carefully studied. In the past, this topic has been ignored by the location researchers. Due to its rising importance, scale of size and the intensive competitiveness, Cash and Carry / Warehouse Club needs a location model as one of their reform strategies. To meet the requirement, this thesis has been dedicated to finding proper location models for the trade sector.

10.2 User's Satisfaction

This thesis is based on cooperative action research. The study was for a membership company (Landmark) with 29 members and 69 outlets. During the study, numerous discussions, meetings and presentations were conducted to show the period results meeting the expectations of the sponsors.

In the competitive climate experienced by the Cash & Carry industry, there has been a consolidation of the depot network. Some operators have been able to develop even against such a background. Within the Landmark organization three companies have made significant additions to their individual networks.

The resulting system LmSDSS has been used to evaluate development opportunities as these networks have expanded. The sensitivity of the system has occasioned some caution in specific settings: relatively large variations in turnover prediction have been obtained for sites that are relatively close to one another. Executive expectation was that such sites should be relatively similar in turnover terms. However, closer analysis revealed that there were micro-location specifics that could explain the shifts. Chief amongst these were moves from one census/demographic cluster area to another. There is a case for applying some sort of smoothing technique to predictions made in adjacent

areas in order to account for the effects that are due to granularity in the available data sets.

The success of the model and its utility is such that one of the largest and most active companies is now seeking to acquire the intellectual property rights to the system from Landmark. The management of the company believes that ownership of the system would confer competitive advantage, and that the system could have commercial potential in other areas. This suggests that the system is seen as commercially viable. The company, should it be successful in acquiring the system, is anxious to update the database to reflect the most recent British census data available (for the census conducted in 2001). This would be followed by a re-calibration of the model, and the incorporation of the national database for the chosen variables. It would then permit the evaluation of any site in the UK on an *ad hoc* basis. With the current more limited database (which covers the operating areas of the members only), consideration of sites further afield requires the purchase of relevant data for the target area.

10.3 Contributions

1. An extensive review and comparison on retail location's history, theories, methods and models has been conducted.
2. A comprehensive analysis on Cash and Carry / Warehouse Club characteristics has been presented. Cash and Carry / Warehouse Club is a particular business situated between the conventional retailer and wholesaler. Serving small retailers, selling goods in bundles and for instant sale are three key characteristics. Cash and carry focuses mainly in the grocery area, and some operate as multiple chains.
3. A retail location model, based on the sample data from a British Cash and Carry company, has been created. The main considerations/methods applied in the model configuration were:
 - a) Because of the identified characteristics of Cash and Carry / Warehouse Club, this thesis did not follow the common research route by using 'gravity' models, but applied a multiple regression method. After careful analyses, this method

was found more suitable for the research object, i.e., the Cash and Carry / Warehouse Club sector.

- b) In the regression analysis, two kinds of trade area measurements were analysed and compared. Although most previous literature used the physical distance as the trade area measurement, 'drive time trade area delimitation' has been identified in this thesis as a better measure and has been selected. This kind of trade area measurement is more relevant to Cash and Carry / Warehouse Club customers' behaviour.
- c) When applying the internal store characteristics and consumer demographic data, the usual method is simply to acquire all kinds of data, input them into the model and then to let the statistics software automatically filter out the significant factors. The methods applied in statistics software, such as forward, backward and stepwise configuration, have their limitations. Multicollinearity is the main problem. Another problem is the p-value selection for accepting a new factor or rejecting an existing factor. Too high or too low a value may cause the model to be wrongly identified. In this thesis, the selected consumer factors are based on the literature study, and on managerial experience. The treatment should guarantee that most data selected are highly related to the target variable - store performance, represented by store turnover. This blending in of tacit knowledge is crucial.
- d) For the competitiveness analysis, two competitiveness measurements, Distance Weighted Competitive Turnover (DWCT) and Distance Weighted Competitor Size (DWCS), have been constructed and tried in the regression analysis. Although not identified as significant predictive factors, they represent an improvement on current competitiveness measurements.

The above considerations and treatments have been shown to be successful because the configured model, MultiRegress, has $R^2 = 96.7\%$ and $R^2 (\text{adj}) = 95.7\%$, which are the highest reported in the retail location research in the literature up to July, 2003. In addition, not only are these two figures very high, but also they are close to

each other. This indicates that all the factors selected in the model make a significant contribution to the model.

4. Some interesting findings are found from the regression analyses:

- a) Depot size is the number one factor, which means that Cash & Carry in the UK has not reached a “saturated” situation. Greater size can bring increased depot turnover;
- b) Full Time Equivalent Employees (FTE) is the second most important factor. This factor is highly related to the quality of service. Therefore, a logical deduction is that the service quality plays a key for depot performance;
- c) The third most significant factor is price competitiveness. This affirms the commonly encountered industry view that ‘low price’ or ‘good value of money’ is one of the most attractive features of a Cash & Carry depot.

5. Some ‘counter-intuitive’ findings are revealed by the study:

- a) Trade area population, a variable normally used to represent the total consumption, was not identified as a significant factor. The probable reason, as analysed in Section 7.5, is the broader coverage area of a Cash & Carry depot;
- b) The percentage of Old Aged Pensioners (OAPs) in the trade area is negatively related to a depot’s turnover. This is contrary to the ‘common knowledge’. The people in this group were assumed to be the major clients of Cash & Carry business customers because they often visit corner stores to get convenience. However, this situation has changed.

6. In the UK, there has been a dispute over whether the multiple outlet supermarkets (multiples) are major competitors to Cash & Carry business. To study this issue, two kinds of competitors, the Cash & Carry only competitors (DWCS) and the multiples inclusive (MDWCS), have been analysed. The fact that R^2 increased 7 % by using

the latter factor leads to the conclusion that the multiples should be considered as significant competitors to the Cash & Carry sector.

7. Because the world is always changing, no matter how good a model is, it will be out of date at some time. Therefore, a dynamic location analysis system becomes important and necessary. This is why a spatial decision support system (LmSDSS) was designed in a way novel to the sector.

The name “Spatial Decision Support Systems” has appeared only in recent years, along with the successful GIS applications and research achievements in marketing. It is true that there are already a number of papers that have discussed this subject in terms of concepts and structure design, but no finished system had been presented in the literature (up to the time when this research was completed). To fill this gap, the research reported here has investigated how to design the system, what kind of features the system should have and what technologies can be and should be utilized.

The designed system integrates technologies such as Database Management Systems, Statistics Software, Geographic Information Systems, Global Positioning System, Analytic Hierarchy Process, Decision Support Systems and others. Although these technologies have been used in various areas, putting them together to form a coherent unity is reported here for the first time.

The resulting system, LmSDSS, is a relatively complex decision support system with over 10,000 lines of codes (The key parts are listed in Appendix III). The system has been successfully integrated into the collaborator company’s Executive Information System (EIS).

Although the study is mainly focused on a British Cash & Carry company and the data collected was based on a project several years ago, the concepts, theories, methods and the resulting models are generalizable and can apply to the whole Cash & Carry / Warehouse Club trade sector in the UK and other areas. The findings and results achieved in the study contribute to knowledge of retail location planning.

10.4 Recommendations of Further Research and Development

This thesis concentrates on the development of location models/systems for a specific industry or even a company. It can be considered a *micro* study. During the study, it was found that macro location structure research to optimize macro location strategy was very necessary. Such a study can concentrate on the question: to what extent, with regard to the total size or turnover, Cash & Carry / Warehouse Club will reach “full structure” in a given area, i.e., where extra size will bring very little increase in turnover. Solving this problem can help Cash & Carry / Warehouse Club businesses or a single company to develop a structure strategy to determine where to open promising outlets, and where to close those declining outlets in a saturated situation, given the systematic considerations of the environment factors of consumer demographics, competition, and so on. This type of ‘network planning’ is an important area of further research.

In this thesis, a half an hour drive time trade area definition is used. This definition is adopted from real management experience. Because of the cost and time constraints, it was not possible to use and test other types of delimitation. Within the auto-delimiting function designed in the Spatial-DSS, further research can be conducted to find out whether half an hour is a suitable size of trade area, whether drive time is a better definition over distance radius, and so on.

The regression model highly fits the researched company’s data. Therefore, it is suitable for the company to make the location decision or assess the member outlets’ performance. However, whether the model suits other companies (or even other types of business) is a question remaining to be addressed with more research.

GPS is a newly emerging technology (at least in the commercial area). During the period when the model was constructed, the author was not able to access this technology. On the basis of other research projects (such as Outdoor Media Exposure Assessment), the author has proposed a way of using this technology in the trade area drive time statistics collection. This proposal needs practical applications to prove its feasibility.

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Appendix I Abbreviations

AA:	Automobile Association
ABI/INFORM:	a popular reference search system relating to over 800 English journals worldwide in the areas of management, business and computer science.
AHP:	Analytic Hierarchy Process
AI:	Artificial Intelligence
API:	Application Programming Interface
CACI:	A Geodemographic Information Service Company
CAD:	Computer Aided Design
DBMS:	DataBase Management Systems
DDE:	Dynamic Data Exchange
DLL:	Dynamic Link Libraries
DSS:	Decision Support Systems
DWCS:	Distance Weighted Competitor Size
DWCT:	Distance Weighted Competitor Turnover
ED:	Enumeration District
EDP:	Electronic Data Processing
EIS:	Executive Information Systems
FRS:	Financial Research Survey
FSA:	c
GDSS:	Group Decision Support Systems
GIS:	Geographic Information Systems
GPS:	Global Positioning System
GUI:	Graphic User Interface
IGD:	IGD (Institute of Grocery Distribution
IT:	Information Techonlogy
MB:	Model Base
MBMS:	Model Base Management Systems
MCI:	Multiplicative Competitive Interaction
MDWCS:	Multiples included Distance Weighted Competitor Size
MIS:	Management Information Systems
OA:	Office Automation

OPCS:	Office of Population Censuses and Surveys
OODBMS:	Object Oriented DataBase Management Systems
PCCF:	Postal Code Conversion File
PCW:	Personal Computer World
RDBMS:	Relational DataBase Management Systems
RQBE:	Relational Query By Example
SA:	Selective Availability
SQL:	Structured Query Languages

Appendix II Tables of Assistant Data

Table A.1 Characteristics Comparison by County

County & Region	Depots	Turn(£m)	Size(ft ²)	Rank	Comp	Rate(£/ft ²)
AVON	8	17.8	60625	5.75	5.88	3177
BEDFORDSHIRE	4	12.0	38750	4.25	4.75	3101
BERKSHIRE	4	21.5	73250	6.25	5.25	3506
BORDERS	1	7.0	27000	7.00	1.00	2593
BUCKINGHAMSHIRE	2	13.0	37500	5.50	4.50	3500
CAMBRIDGESHIRE	3	22.3	43333	4.00	5.33	4516
CENTRAL SCOTLAND	3	10.9	27000	4.33	4.67	3946
CHESHIRE	7	9.8	33714	5.29	4.71	4657
CLEVELAND	5	15.4	54000	5.00	6.80	2805
CLWYD	2	6.0	32500	3.00	5.50	2028
CORNWALL AND ISLES	6	6.0	22000	5.17	5.33	3056
CUMBRIA	6	6.8	27417	5.00	4.50	2792
DERBYSHIRE	4	10.1	30625	4.50	3.75	3463
DEVON	8	16.0	40625	5.75	6.38	3715
DORSET	5	11.7	57000	6.00	6.20	2299
DUNFRIES AND GALLOWAY	2	9.5	23500	5.50	3.50	3964
DURHAM	4	14.5	47250	5.25	6.00	2940
DYFED	4	6.3	20500	6.50	5.00	3060
EAST SUSSEX	4	10.6	45750	5.75	5.00	2676
ESSEX	7	13.6	52811	6.00	5.57	2716
FIFE	4	12.0	30000	4.00	3.75	3858
GLOUCESTERSHIRE	3	11.7	76667	8.00	7.33	1465
GRAMPIAN	5	12.4	47320	6.20	2.80	2754
GREATER MANCHESTER	17	17.1	48647	5.29	5.12	3872
GWENT	4	6.5	23750	3.75	4.00	2896
GWYNEDD	3	9.0	42000	5.67	8.33	2204
HAMPSHIRE	4	29.3	90800	7.00	6.50	3207
HEREFORD AND WORCESTER	6	8.6	31833	6.17	5.83	2641
HERTFORDSHIRE	3	13.0	33333	3.33	5.00	4113
HIGHLAND	2	6.0	15000	5.50	1.50	4000
HUMBERSIDE	7	14.4	46429	6.57	4.86	3018
ISLANDS	2	6.0	8500	5.50	5.00	6750
KENT	6	20.8	45750	4.83	5.50	4499
LANCASHIRE	9	7.1	37778	4.11	4.56	2013
LEICESTERSHIRE	8	17.8	40375	4.88	6.00	6664
LINCOLNSHIRE	5	8.4	25800	6.20	6.60	2966
LONDON	41	23.6	47370	4.41	5.93	5551
LOTHIAN	5	20.0	58700	5.40	6.80	3764

MERSEYSIDE	10	25.0	69650	5.60	5.10	4239
MID GLAMORGAN	2	7.5	31500	8.50	6.00	2379
NORFOLK	6	14.5	41833	6.50	5.67	3541
NORTH YORKSHIRE	3	10.7	47000	7.33	6.00	2226
NORTHAMPTONSHIRE	3	17.7	56667	5.33	5.67	3084
NORTHUMBERLAND	2	7.5	20000	4.50	3.50	3500
NOTTINGHAMSHIRE	8	16.8	50625	5.50	4.88	3303
OXFORDSHIRE	2	8.3	27500	5.50	2.50	2839
SHROPSHIRE	2	10.0	55000	9.00	5.50	1696
SOMERSET	6	7.8	27500	5.00	4.17	2703
SOUTH GLAMORGAN	4	26.3	52250	6.25	6.75	4768
SOUTH YORKSHIRE	10	17.9	47800	4.10	5.60	3778
STAFFORDSHIRE	6	18.8	50833	4.50	5.00	3875
STRATHCLYDE	20	18.3	45200	4.90	4.45	4304
SUFFOLK	5	11.3	43860	5.00	4.80	2666
SURREY	4	10.3	35000	5.50	5.75	3133
TAYSIDE	6	8.9	36500	6.83	4.00	3029
TYNE AND WEAR	11	19.6	58182	6.36	6.55	3301
WARWICKSHIRE	5	13.2	38600	5.60	3.00	2716
WEST GLAMORGAN	3	15.8	83000	8.00	7.33	1942
WEST MIDLANDS	24	15.7	58458	4.25	6.00	2478
WEST SUSSEX	3	10.7	31750	5.00	4.00	3307
WEST YORKSHIRE	11	21.4	78545	6.73	6.55	2622
WILTSHIRE	2	7.3	48250	6.00	8.00	1512

Note: 'Depots' meant the depot number in the county. The other figures were averaged by the number of depots in each county.

Table A. 2 Demographics Comparison by County

County & Region	Population	Income(£)	%Actw	%Carl	%Oaps	ComptNo
AVON	645175	12853	21.73	27.2	15.55	5.00
BEDFORDSHIRE	698993	15476	22.05	23.3	12.48	2.25
BERKSHIRE	949917	17639	23.00	21.2	11.72	4.25
BORDERS	35449	10498	22.97	32.6	16.55	0.00
BUCKINGHAMSHIRE	736742	17209	22.55	19.6	12.19	2.50
CAMBRIDGESHIRE	209016	13550	21.31	25.0	14.72	0.33
CENTRAL SCOTLAND	422962	12128	21.60	37.7	12.93	3.67
CHESHIRE	655145	12594	20.59	30.5	14.96	3.86
CLEVELAND	544073	10546	18.98	40.6	13.48	4.20
CLWYD	218816	12410	19.37	29.1	17.62	1.50
CORNWALL AND ISLES	128426	10385	18.64	26.2	17.60	1.17
CUMBRIA	113950	10927	21.15	31.1	16.28	1.00

DERBYSHIRE	829333	11750	20.58	35.6	16.10	9.50
DEVON	220717	10827	19.85	27.9	18.25	1.25
DORSET	346564	13930	19.76	24.6	20.42	1.60
DUNFRIES AND GALLOWAY	42843	10106	20.39	32.9	14.51	0.00
DURHAM	782745	10181	19.67	44.0	14.99	7.75
DYFED	110922	11656	18.49	28.0	15.69	1.25
EAST SUSSEX	275338	13796	19.95	33.8	22.01	0.50
ESSEX	691222	15792	20.96	25.3	14.36	3.00
FIFE	220255	11868	20.72	38.1	14.97	2.00
GLOUCESTERSHIRE	378753	13219	21.82	25.0	15.43	2.00
GRAMPIAN	200274	12988	22.49	35.8	12.77	2.40
GREATER MANCHESTER	2154511	11529	20.48	40.0	15.65	18.18
GWENT	504245	11593	19.37	32.4	14.73	3.75
GWYNEDD	100033	11785	18.71	29.6	17.59	1.00
HAMPSHIRE	824871	15471	21.56	24.5	13.82	2.00
HEREFORD AND WORCESTER	232976	12591	21.18	24.1	15.72	2.00
HERTFORDSHIRE	966329	16211	22.26	24.2	13.00	5.67
HIGHLAND	50524	12277	21.90	31.9	12.30	0.00
HUMBERSIDE	286295	11825	19.44	38.3	15.52	2.71
ISLANDS	14061	12495	21.40	32.4	13.67	0.00
KENT	400859	14346	20.19	27.5	16.42	0.83
LANCASHIRE	777720	11802	20.55	34.7	16.45	5.78
LEICESTERSHIRE	778146	11989	21.60	31.2	14.86	9.88
LINCOLNSHIRE	126451	12498	19.67	27.0	17.63	1.00
LONDON	1653009	15266	22.33	39.7	13.49	10.88
LOTHIAN	605953	12390	23.24	44.4	15.12	6.40
MERSEYSIDE	1334223	11559	20.02	40.2	15.36	8.10
MID GLAMORGAN	472724	11053	18.60	35.5	14.45	3.00
NORFOLK	207854	12656	20.10	26.8	18.11	1.50
NORTH YORKSHIRE	155182	12841	21.15	30.1	17.61	0.33
NORTHAMPTONSHIRE	391188	13424	22.26	26.8	13.48	0.33
NORTHUMBERLAND	303731	11416	20.75	38.4	16.36	0.50
NOTTINGHAMSHIRE	723482	11866	20.77	33.8	15.31	10.25
OXFORDSHIRE	310937	13845	22.57	22.3	12.57	1.50
SHROPSHIRE	212624	12145	20.63	26.5	15.04	0.00
SOMERSET	191363	12554	20.44	22.0	16.82	1.50
SOUTH GLAMORGAN	633931	12193	20.00	34.4	14.14	6.75
SOUTH YORKSHIRE	1067442	11298	19.62	40.2	15.59	9.60
STAFFORDSHIRE	920238	11652	20.70	32.7	15.20	7.17
STRATHCLYDE	1038495	11048	20.30	49.6	14.26	12.30
SUFFOLK	210697	13422	20.45	25.4	15.71	0.80
SURREY	1347592	17989	22.82	20.8	13.03	4.75
TAYSIDE	155977	11987	21.73	38.6	16.25	1.50
TYNE AND WEAR	1191852	10029	19.72	48.6	15.54	10.91
WARWICKSHIRE	544852	12358	21.37	28.5	15.15	3.80

WEST GLAMORGAN	401781	11115	18.06	34.7	16.13	3.00
WEST MIDLANDS	1644194	10814	20.06	38.4	15.02	15.13
WEST SUSSEX	420026	14004	20.21	28.7	20.96	1.33
WEST YORKSHIRE	1595302	11547	20.74	41.3	15.53	11.73
WILTSHIRE	258322	13283	22.28	24.8	14.46	0.50

Note: Here, 'Population' was the average trade area population, not the whole population, in the county. The other figures were also averaged by the trade area in each county.

Table A.3 Characteristics Comparison by Group

Group Name	Depot Number	Size (ft ²)	Rate (£/ft ²)	Depot Rank	Price Comp
Batley's	13	95385	3534	7.3	7.1
Booker	146	37072	3140	6.1	5.3
Hancock's	6	23333	5062	5.2	6.3
Landmark	71	55380	3730	5.4	6.2
M6	1	80000	2500	8.0	6.0
Makro	20	101850	3766	7.5	4.8
Mojo	14	24714	2423	4.6	3.9
N & P	53	85009	3551	6.3	7.0
Sterling	12	32000	3115	4.3	4.7
Today's	94	26011	4053	4.0	5.2
Independent	15	20200	3170	3.7	4.9
Total	447	46818	3515	5.5	5.6

Table A.4 Characteristics Comparison by Scale

Depot Size	Depot Number	Turn/Size £/ft ²	Depot Rank	Price Comp
<10000	12	6280	2.3	3.6
10000~100000	386	3456	5.3	5.5
>=100000	49	3306	7.5	6.6

Table A. 5 Data Used in Regression Analysis

POSTCODE	TURN	SIZE	RANK	COMP	EMPLOY	POPU	INCM	ACTW	CARL	PENS	DWCT	DWCS	CUST
AB23 8HG	17.0	50000	4	3	71	234070	13134	23.34	36.90	12.70	84.8	442147	263
B 8 1DL	35.6	93000	7	7	64	1710179	10795	19.89	39.50	14.96	474.5	2126328	1991
B 12 0TY	7.0	35000	2	6	0	1553740	10686	19.85	40.60	15.32	305.5	1851415	1819
B 66 2NW	19.0	110000	7	8	0	1994999	10341	19.65	41.10	15.12	414.7	2227168	2367
BA 3 4BB	15.0	40000	4	4	0	237873	13089	21.69	24.50	15.62	74.7	378345	259
BS 4 5QW	24.0	85000	7	8	0	666457	12793	21.97	29.10	15.70	143.7	867080	745
CA11 9BQ	4.0	60000	7	4	14	96192	11080	21.77	29.00	16.22	31.0	206681	130
CA28 8YD	4.0	12500	3	4	0	124739	10163	19.89	34.50	14.82	22.8	146966	174
CF 1 8AQ	40.0	60000	2	9	0	666124	12206	20.00	33.90	13.97	323.2	945146	671
CR 9 4QJ	20.0	100000	7	6	0	1411956	16709	23.36	31.60	14.03	160.0	1631415	1370
CV 1 4JF	18.5	68000	5	7	0	802031	11568	21.06	32.80	15.13	169.2	963070	971
DD 1 9PU	18.0	50000	8	6	0	226172	11272	21.77	46.20	16.47	79.3	502877	287
DD 3 8SJ	13.0	70000	7	6	24	229274	11281	21.77	46.00	16.47	68.8	502877	295
DG 9 7DD	6.0	22000	3	3	13	18909	9760	18.98	34.40	13.85	20.0	39588	28
DN36 4AT	9.5	38000	7	5	26	191776	12051	19.41	35.10	14.64	52.4	226177	218
DY 9 8HX	7.7	38000	5	4	23	1092013	10926	20.59	36.90	15.63	216.4	1378164	1152
E 2 9HQ	38.0	80000	3	7	0	1370682	12749	20.54	53.20	13.13	290.1	1400155	1732
EH 7 4NH	23.0	40000	6	7	0	477428	12372	23.43	46.30	16.05	206.4	816157	603
EH11 2AX	15.0	40000	6	7	0	593424	12635	23.44	43.50	14.87	189.1	882895	688
FK 1 1RY	6.6	20000	1	4	21	434542	12022	21.61	38.10	13.00	102.2	542153	491
G 5 9XR	67.0	130000	6	8	204	1364569	10912	20.28	53.80	14.48	526.8	2116178	1392
G 21 2XF	21.0	55000	6	7	0	1617676	10837	20.20	52.70	14.28	457.4	2266376	1653
G 33 4UL	16.0	90000	8	6	32	1679394	10938	20.26	51.80	14.18	446.6	2279976	1728
HR 2 6LB	5.0	25000	6	5	0	104818	12078	20.77	25.10	16.02	39.9	254823	126
HX 1 4PW	9.9	28000	4	4	42	917758	11187	20.55	42.20	15.33	227.3	1065278	1440
KA 1 3JQ	16.0	45000	7	7	0	291641	12230	20.43	39.90	14.08	87.7	445853	407
KA 8 9JY	9.5	30000	6	4	19	239843	11900	20.41	40.70	14.47	91.0	366818	323
KW15 1AR	3.0	5000	4	5	4	19612	12800	19.79	26.20	13.90	10.5	5001	24
KY 1 2YX	25.0	52000	6	7	0	218248	11464	20.45	39.10	15.07	117.2	305148	316
KY15 5GE	5.0	12000	2	3	11	160322	11683	20.71	39.10	15.56	35.1	201530	256
L 6 5BN	17.0	35000	6	5	0	1473278	10704	19.45	45.10	14.92	278.4	1237032	1439
L 9 5AL	62.0	105000	7	8	0	1502943	11180	19.76	42.20	14.79	363.7	1344323	1495
LE 4 5PN	42.0	110000	7	8	0	702246	12130	21.76	30.60	14.64	257.0	798553	863
LE 5 0HU	13.0	44000	6	7	0	561315	11795	21.59	32.70	14.85	158.8	733747	713
LL18 2LS	5.0	20000	2	7	0	143151	12146	18.42	30.30	20.22	16.8	124018	197
LL57 4SU	13.0	36000	4	9	56	102233	11898	18.56	28.10	15.61	46.1	93672	165
LS13 4LQ	19.0	105000	7	8	0	1517520	11668	20.81	41.30	15.62	332.0	1779023	2157
LU 1 1DE	20.0	70000	7	7	0	783733	15402	22.07	23.70	12.27	144.9	1012787	676
M 10 8WP	31.0	100000	8	9	0	1769827	10938	20.31	44.00	15.88	508.1	1934201	2289
ML 3 0DS	26.0	55000	8	8	46	1220820	10709	20.16	53.20	14.12	420.2	1808776	1280
N 4 1DW	25.0	25000	5	7	0	1503755	14087	21.69	48.80	13.35	321.6	1578545	1868
N 17 0XX	23.0	85000	5	8	0	1733485	14717	21.50	42.20	13.49	302.7	1841877	1875
NE11 0RQ	25.0	80000	4	8	46	1308602	10090	19.81	48.30	15.57	508.4	1484378	1468
NE29 7XB	10.0	40000	3	6	23	1234927	10086	19.81	48.60	15.76	270.8	1438494	1348
NE61 6JS	12.0	30000	5	5	0	466852	11036	20.56	41.90	16.24	48.9	373454	456
NG 7 2UT	35.0	100000	8	7	0	876880	11722	21.20	35.30	15.40	491.0	1250164	1084
NP 2 1ZE	6.0	30000	2	4	17	495368	10317	18.24	37.70	14.45	119.8	556425	590
NP 5 3AH	6.5	15000	2	4	36	182625	12405	19.60	23.80	15.77	21.6	109871	189
NP 9 5JN	9.0	30000	6	5	0	790469	11911	19.86	33.70	14.07	229.0	1046428	910
NW 2 6LT	52.0	90000	7	8	0	2292456	16337	22.90	37.30	13.23	478.9	2572224	2462
NW10 6UR	24.0	30000	2	7	0	1876547	16131	23.40	40.30	12.71	610.7	2119938	2196
NW10 7BW	65.0	110000	5	7	0	1971421	16306	23.30	39.10	12.79	602.1	2258677	2267
PA 1 1QP	9.0	12000	2	5	0	1246997	10829	20.13	55.00	14.80	412.4	1876326	1336
PH 1 3EE	7.5	30000	5	4	23	102598	12478	21.73	32.90	15.64	31.9	215818	137
RM 3 8SB	17.0	90000	6	8	0	1424860	15119	20.95	29.70	14.54	130.3	2073562	1163
S 70 3PA	10.0	30000	5	5	23	985377	10992	19.58	41.40	15.61	230.2	1083671	1247
SA 6 8QZ	16.0	110000	8	8	0	424722	11118	18.01	34.60	16.25	195.1	601852	558
SE12 0RJ	40.0	100000	7	8	0	1473121	14681	21.97	39.60	14.38	218.7	1410580	1366
SK 4 1EB	13.0	27000	4	6	36	2282043	11778	20.44	39.10	15.61	449.2	2228126	2632

SK 4 2JP	54.0	100000	7	7	0 2321604 11775	20.45	39.00	15.62	537.9	2269779	2682
SM 1 4JF	4.0	10000	5	5	22 1344840 16761	23.11	31.10	14.25	123.6	1655283	1294
SS11 8DJ	3.0	24000	6	3	0 933903 16456	20.88	24.80	14.81	86.7	1268657	737
SY11 4JB	15.0	70000	9	7	0 153407 12162	20.32	26.80	16.11	48.4	147642	184
TA 6 4BH	8.0	30000	6	4	24 266834 12389	20.07	24.40	17.99	43.1	360742	318
TS 3 8AL	20.0	60000	6	8	40 512306 10701	18.99	39.90	13.38	158.9	592259	493
UB 2 5LG	48.0	70000	5	7	0 2504939 17339	23.12	29.10	12.82	512.4	3147770	2464
WA 8 7SB	3.0	20000	3	4	6 1455029 11168	19.72	41.50	14.48	321.5	1599119	1421
WS 2 7NS	25.0	75000	8	7	48 1301399 10543	19.85	38.50	14.71	329.8	1623731	1588
WV 3 0DQ	22.0	71000	7	6	45 1073443 10912	20.21	35.10	14.51	254.4	1463430	1156
ZE 1 0PX	9.0	12000	7	5	41 8509 12189	23.01	38.60	13.44	29.5	12001	12

Appendix III Source Codes

```
* *****
*
* 23/11/95          LM_MENU.MPR          14:43:58
*
* *****
*
* Author's Name: Xiaoyong Tao
*
* Copyright (c) 1994 Company Name
* Address
* City,      Zip
*
* Description:
* This is the Event-Driven menu of LmSDSS.
*
* *****

* *****
*
*                               Menu Definition
*
* *****
*

SET SYSMENU TO

SET SYSMENU AUTOMATIC
set talk off
set exclusive on
on key label ALT+F9 set sysmenu to defa

public iChannel
ichannel=0
iChannel=ddeinitiate("Winword","System")
on key label f12 do lm_scrprn

set path to lmsdss
set help to lm_help
clear
* *****
*
*                               Windows Window definitions
*
* *****
*

IF NOT WEXIST("lm_menu")
    DEFINE WINDOW lm_menu ;
        AT 0.000, 0.000 ;
        SIZE 30.923,126.800 ;
        FONT "MS Sans Serif", 8 ;
        FLOAT ;
        title "LmSDSS Main Menu" ;
        NOCLOSE ;
        MINIMIZE ;
        SYSTEM
ENDIF
```

```

*          *****
*          *
*          *          LM_DTQ/Windows Screen Layout
*          *
*          *****
*
*#REGION 1
IF WVISIBLE("lm_menu")
    ACTIVATE WINDOW lm_menu SAME
ELSE
    ACTIVATE WINDOW lm_menu NOSHOW
ENDIF

if .not. file("lmsdss\lm_deftp.idx")
    do c_index
endif

do while .t.
close database
release all except ichannel
mch=99
mainskip=.f.

@0,8 say 'LANDM' font 'Times New Roman',22 style 'B'
@0,29 say 'A' font 'Times New Roman',22 style 'B' color
RGB(255,0,0,255,255,255)
@0,33 say 'RK' font 'Times New Roman',22 style 'B'
@3,0 say 'Spatial Decision Support System' font 'Times New Roman',14
style 'B'

@ 6,1 SAY 'lm_regin.bmp' BITMAP size 30,50 ISOMETRIC

DEFINE PAD file OF _MSYSMENU PROMPT "\<File" COLOR SCHEME 3 key ALT+F
;
    skip for mainskip
DEFINE PAD enquiry OF _MSYSMENU PROMPT "\<Enquiry" COLOR SCHEME 3 key
ALT+E ;
    skip for mainskip
DEFINE PAD maintain OF _MSYSMENU PROMPT "\<Maintain" COLOR SCHEME 3
key ALT+M ;
    skip for mainskip
DEFINE PAD map of _MSYSMENU PROMPT "Ma\<p" COLOR SCHEME 3 key ALT+P ;
    skip for mainskip
DEFINE PAD sdss OF _MSYSMENU PROMPT "\<SDSS" COLOR SCHEME 3 key ALT+S
;
    skip for mainskip
DEFINE PAD _msm_system OF _MSYSMENU PROMPT "\<Help" COLOR SCHEME 3 key
ALT+H ;
    MESSAGE "Access information for learning and using LMSDSS" ;
    skip for mainskip

ON PAD file OF _MSYSMENU ACTIVATE POPUP file
ON PAD enquiry OF _MSYSMENU ACTIVATE POPUP enquiry
ON PAD maintain OF _MSYSMENU ACTIVATE POPUP maintain
ON PAD map OF _MSYSMENU ACTIVATE POPUP map
ON PAD sdss OF _MSYSMENU ACTIVATE POPUP sdss
ON PAD _msm_system OF _MSYSMENU ACTIVATE POPUP _msystem

DEFINE POPUP file MARGIN RELATIVE SHADOW COLOR SCHEME 4
DEFINE BAR 1 OF file PROMPT "\<Print..." ;
    MESSAGE "Select the result needed to be printed or showed out"

```

```

DEFINE BAR 2 OF file PROMPT "E\<xit" ;
    MESSAGE "Exit this system"
on selection popup file do file_pro

DEFINE POPUP enquiry MARGIN RELATIVE SHADOW COLOR SCHEME 4
DEFINE BAR 1 OF enquiry PROMPT "Depot \<Information" ;
    MESSAGE "Information for Cash and Carry Depots"
DEFINE BAR 2 OF enquiry PROMPT "\<Demographic Info" ;
    MESSAGE "Demographic Information in a Certain Area"
DEFINE BAR 3 OF enquiry PROMPT "Depot \<Comparison" ;
    MESSAGE "Compare the Characteristics for Cash and Carry Depots"
DEFINE BAR 4 OF enquiry PROMPT "\<Multiples" ;
    MESSAGE "Information for the main multiples' outlets"
DEFINE BAR 5 OF enquiry PROMPT "C\<ustomers" ;
    MESSAGE "Information for the independent retailers"
DEFINE BAR 6 OF enquiry PROMPT "\<Overlap" ;
    skip for .t. ;
    MESSAGE "Check the overlapping area of catchment areas"
ON SELECTION popup enquiry do enqu_pro

DEFINE POPUP maintain MARGIN RELATIVE SHADOW COLOR SCHEME 4
DEFINE BAR 1 OF maintain PROMPT "\<Modify" ;
    MESSAGE "Modify the information in the main databases"
DEFINE BAR 2 OF maintain PROMPT "\<Reindex" ;
    MESSAGE "Rebuild the index files for the databases"
DEFINE BAR 3 OF maintain PROMPT "E\<xport" ;
    MESSAGE "Export the data for turnover forecast model analysis"
*DEFINE BAR 4 OF maintain PROMPT "\<Verify" ;
*    MESSAGE "Keep the integrity of the databases in the system"
*DEFINE BAR 5 OF maintain PROMPT "\<Demo Instal" ;
*    MESSAGE "Re-instal demographic information and/or re-
construction"+;
*        "competition database"
*DEFINE BAR 5 OF maintain PROMPT "I\<nport" ;
*    SKIP FOR .t.

on selection popup maintain do maint_pro

DEFINE POPUP map MARGIN RELATIVE SHADOW COLOR SCHEME 4
DEFINE BAR 1 OF map PROMPT "D\>rive Time" ;
    SKIP FOR .t.
DEFINE BAR 2 OF map PROMPT "Di\>stance Time" ;
    SKIP FOR .t.
DEFINE BAR 3 OF map PROMPT "Pol\>ygon" ;
    SKIP FOR .t.
DEFINE BAR 4 OF map PROMPT "Re\>gion" ;
    SKIP FOR .t.

DEFINE POPUP sdss MARGIN RELATIVE SHADOW COLOR SCHEME 4
DEFINE BAR 1 OF sdss PROMPT "\<Modelling" ;
    MESSAGE "Automatically abstracts the necessary information
and"+;
        " then run the statistics package to get the model"
DEFINE BAR 2 OF sdss PROMPT "\<Analysis" ;
    MESSAGE "Analysing the depot performance under some changed
environments"
DEFINE BAR 3 OF sdss PROMPT "A\<ssess" ;
    MESSAGE "Showing the assessment results by data list and scatter
graph"
DEFINE BAR 4 OF sdss PROMPT "\<Predict" ;
    MESSAGE "Runing the forecast model from the data typed in"
DEFINE BAR 5 OF sdss PROMPT "\<Residual" ;
    MESSAGE "Residual analysis about the turnover model"

```

```

DEFINE BAR 6 OF sdss PROMPT "A\<HP" ;
    MESSAGE "Expertise Judgment Evaluation Model"
DEFINE BAR 7 OF sdss PROMPT "Lo\<cation" ;
    SKIP FOR .t.
DEFINE BAR 8 OF sdss PROMPT "St\<ategy" ;
    SKIP FOR .t.

on selection popup sdss do sdss_pro

DEFINE POPUP _msystem MARGIN RELATIVE SHADOW COLOR SCHEME 4
DEFINE BAR _mst_help OF _msystem PROMPT "\<Contents" ;
    KEY F1, "" ;
    MESSAGE "Display help contents"
DEFINE BAR _mst_hpsch OF _msystem PROMPT "\<Search for Help on..." ;
    MESSAGE "Search for help topic by typing or selecting a keyword"
DEFINE BAR _mst_hphow OF _msystem PROMPT "\<How to Use Help" ;
    MESSAGE "Display instructions for using help"
DEFINE BAR _mst_sp100 OF _msystem PROMPT "\-"
DEFINE BAR _mst_dbase OF _msystem PROMPT "\<dBASE Help..." ;
    MESSAGE "Shows the FoxPro equivalent of a dBASE
command/function"
DEFINE BAR _mst_sp200 OF _msystem PROMPT "\-"
DEFINE BAR _mst_about OF _msystem PROMPT "\<About FoxPro..." ;
    MESSAGE "Display information about FoxPro and the system
configuration"
DEFINE BAR _mst_sp300 OF _msystem PROMPT "\-"
DEFINE BAR _mst_calcu OF _msystem PROMPT "Ca\<lculator" ;
    MESSAGE "Perform calculations"
DEFINE BAR _mst_diary OF _msystem PROMPT "Calendar/D\<iary" ;
    MESSAGE "Check dates and keep track of appointments"
DEFINE BAR _mst_filer OF _msystem PROMPT "\<Filer" ;
    MESSAGE "Manage files and directories"
DEFINE BAR _mst_puzzl OF _msystem PROMPT "Pu\<zzle" ;
    MESSAGE "Solve a puzzle"
DEFINE BAR _mst_ascii OF _msystem PROMPT "\<Special" ;
    MESSAGE "Solve a puzzle"

store 99 to mchf,mche,mchm,mchs

@0.5,58 to 7.5,126
@0.7,80 say 'File Manager' style 'B'
@2,60 get mchf pict '@*BHT \?lm_exit.bmp;'+;
    'lm_print.bmp' size 3,12
@5,61 say "ExitSystem"
@5,75 say 'PrintFiles'

@7.5,58 to 14.5,126
@7.7,80 say 'Information Enquiry' style 'B'
@9,60 get mche pict '@*BHT lm_help.bmp;lm_earth.bmp;lm_graph.bmp;'+;
    'lm_house.bmp;lm_credt.bmp';
    size 3,12
@12,62 say 'Depots'
@12,73 say 'Demographic'
@12,89 say 'Depot'
@12,101 say 'Multiples'
@12,112 say 'Customers'
@13,60 say 'Information'
@13,73 say 'Information'
@13,87 say 'Comparison'
@13,100 say 'Information'
@13,112 say 'Information'

@14.5,58 to 21.5,126

```

```

@14.7,80 say 'Database Maintenance' style 'B'
@16,60 get mchm pict '@*BHT lm_chng.bmp;lm_reind.bmp;lm_expt.bmp' size
3,12
@19,60 say 'DepotData'
@19,73 say 'Databases'
@19,89 say 'Export'
@20,60 say 'Modification'
@20,73 say 'Reindex'
@20,89 say ' Data'

@21.5,45 to 28.5,126
@21.7,80 say 'Decision Support' style 'B'
@23,47 get mchs pict '@*BHT lm_modl.bmp;lm_anal.bmp;lm_asst.bmp;'+;
'lm_pred.bmp;lm_rsd1.bmp;lm_ahp.bmp' size 3,12
@26,47 say 'Regression'
@26,60 say 'Performance'
@26,73 say 'Performance'
@26,87 say 'Turnover'
@26,101 say 'Residual'
@26,116 say 'AHP'
@27,48 say 'Modeling'
@27,62 say 'Analysis'
@27,73 say 'Assessment'
@27,88 say 'Predict'
@27,101 say 'Analysis'
@27,114 say 'Modeling'

read cycle
IF WVISIBLE("lm_menu")
    ACTIVATE WINDOW lm_menu SAME
ELSE
    ACTIVATE WINDOW lm_menu NOSHOW
ENDIF

mainskip=.t.

do case

case mchf=1
    do lm_quit
case mchf=2
    do lm_print

case mche=1
    do lm_dtq
case mche=2
    do lm_dmgh
case mche=3
    do lm_show
case mche=4
    do lm_multq
case mche=5
    do lm_foodq

case mchm=1
    do lm_chng1
case mchm=2
    do re_indx
case mchm=3
    do lm_expl

case mchs=1
*    do lm_rgss

```

```

case mchs=2
    do lm_anal
case mchs=3
    do lm_asst
case mchs=4
    do lm_pred
case mchs=5
    do lm_foct with ''
case mchs=6
    do lm_ahp

endcase
mainskip=.f.

enddo

procedure lm_quit
release window lm_menu

=DdeTerminate(iChannel)
on key label f12
set sysmenu to defa
set help to foxhelp
*    set path to
clear all
*return
cancel

procedure lm_scrprn
=DdeExecute(ichannel,"[EditPaste]")           && Paste the
message from

    && the Clipboard into Word.
=DdeExecute(ichannel,"[FilePrint .Range=0]")   && Print out the
message

    && Range=0 means to print

    && all the contents
=DdeExecute(ichannel,"[EditSelectAll]")        && Select all
the contents
=DdeExecute(ichannel,"[EditClear]")            && Clear the
contents. Make

    && the current Word document

    && be empty.

procedure file_pro
mainskip=.t.
do case
case bar()=1
    do lm_print
case bar()=2
    do lm_quit
endcase
mainskip=.f.

procedure maint_pro
mainskip=.t.
do case
case bar()=1
    do lm_chng1

```



```

case bar()=2
    do re_indx
case bar()=3
    do lm_exp1
*case bar()=4
*    do lm_verif
*case bar()=6
*    do lm_comp
endcase
mainskip=.f.

procedure re_indx
    use lm_dept index lm_deptd,lm_deptp,lm_deptc
    reindex
    use lm_mult index lm_multp
    reindex
    use lm_cust index lm_custp
    reindex
    use county_d index county_n
    reindex

procedure enqu_pro
mainskip=.t.
do case
case bar()=1
    do lm_dtq
case bar()=2
    do lm_dmgh
case bar()=3
    do lm_show
case bar()=4
    do lm_multq
case bar()=5
    do lm_foodq
endcase
mainskip=.f.

procedure graph_pro
mainskip=.t.
do case
case bar()=3
    do lm_show
endcase
mainskip=.f.

procedure sdss_pro
mainskip=.t.
do case
case bar()=1
    do lm_rgss
case bar()=2
    do lm_anal
case bar()=3
    do lm_asst
case bar()=4
    do lm_pred
case bar()=5
    do lm_foct with ''
case bar()=6
    do lm_ahp
endcase
mainskip=.f.

```

```
procedure c_index
set safe off
use lm_dept
index on depot to lmsdss\lm_deptd
index on post_code to lmsdss\lm_deptp
index on county to lmsdss\lm_deptc
use lm_mult
index on postcode to lmsdss\lm_multp
use lm_cust
index on postcode to lmsdss\lm_custp
use county_d
index on county to lmsdss\county_n
use
set safe on
```

```

*          *****
*
* 13/02/95          LM_RGSS.PRG          14:48:38
*
*          *****
*
* Author's Name: Xiaoyong Tao
*
* Copyright (c) 1994 Company Name
* Address
* City,      Zip
*
* Description:
* Provide the Windows interface for the regression analysis
* using a stactstcisc package (MINITAB)
*
*          *****

```

```

close database
ms=space(20)
sele 5
use lm_exp11
mmmsg=trim(msg)+" (W="+str(weight,5,1)+" )"
mweight=weight
use lm_exp1
nn=reccount()
set safety off
copy stru to aaa exte
set safety on
sele 8
use aaa
dele for field_type<>'N'
pack
n=reccount()
mtype=1
mi=1.0
dimension factor(n),factor1(n),factor2(n),factor3(n)
i=0
scan
    i=i+1
    factor(i)=field_name
endscan
for i=1 to n
    factor2(i)=' '
    factor1=0
    factor3=0
endfor

```

on key label f1 help p Modelling

```

*          *****
*
*          Windows Window definitions
*
*          *****
*

```

```

IF NOT WEXIST("lm_rgss")
    DEFINE WINDOW lm_rgss ;
        AT 0.000, 0.000 ;
        SIZE 30,126.800 ;
        FONT "MS Sans Serif", 8 ;
        title "Depot Regression Analysis "+mmmsg ;
        FLOAT ;

```

```

        NOCLOSE ;
        MINIMIZE ;
        SYSTEM
ENDIF

IF NOT WEXIST("lm_rgss1")
    DEFINE WINDOW lm_rgss1 ;
        AT 0.000, 0.000 ;
        SIZE 30,126.800 ;
        FONT "MS Sans Serif", 8 ;
        title "Depot Regression Analysis Results" ;
        FLOAT ;
        MINIMIZE ;
        SYSTEM
ENDIF

*#REGION 1
clear
ml=0
mf=1
idpt=0
mf2=1
k=0
do while .t.

IF WVISIBLE("lm_rgss")
    ACTIVATE WINDOW lm_rgss SAME
ELSE
    ACTIVATE WINDOW lm_rgss NOSHOW
ENDIF

    @0.5,10 say "The factors" style "B"
    @2,10 get mf from factor size 16,20 ;
        function '&T' FONT "MS Sans Serif", 8 ;
        STYLE "B" valid factor_type()

    @0.5,36 say "The factors selected" style "B"
    @2,36 get mf2 from factor2 size 16,20 ;
        function '&T' FONT "MS Sans Serif", 8 ;
        STYLE "B" valid factor_dele()
    @8,70 say "The regression model" style "B"
    @ 10,70 GET mmodel ;
        PICTURE "@*HT \<Linear;\<Exponential" ;
        SIZE 1.769,8.667,1.333 ;
        DEFAULT 1 ;
        FONT "MS Sans Serif", 8 ;
        STYLE "B" valid model_type()
    @15,72 say 'Data Decimal' style 'B'
    @17,72 GET mdec SPINNER 1, 0, 9 ;
        PICTURE "@K" ;
        SIZE 0.846, 5.400 ;
        DEFAULT 2 ;
        FONT "MS Sans Serif", 8

    mcheck=3
    @ 25,76 GET mcheck ;
        PICTURE "@*HT \!\<OK;\?\<Quit" ;
        SIZE 1.769,8.667,1.333 ;
        FONT "MS Sans Serif", 8 ;
        STYLE "B"
    read cycle

```

```

do case
case mcheck=1
    if k=0 or idpt=0
        ??chr(7)
        loop
    else
        hide window lm_rgss
        do export_data
        do regress
        do display
        clear
    endif
case mcheck=2
    exit
endcase
enddo
RELEASE WINDOW lm_rgss
RELEASE WINDOW lm_rgssl

function factor_type
@0.5,73 say "The factor's appearance" style "B"
@ 2,62 GET mtype ;
    PICTURE "@*HT \<Pow;\<Exp;\<Log;\<Dpt;\<Cancel" ;
    SIZE 1.769,8.667,1 ;
    DEFAULT 1 ;
    FONT "MS Sans Serif", 8 ;
    STYLE "B" valid factor_t1()
read
do case
case mtype=4
    idpt=mf
    @22,0
    @22,0 say trim(factor(idpt))+ ' = ' style 'B'
    ml=col()
case mtype<4
    if mf=idpt
        ??chr(7)
    else
        k=k+1
        do case
        case mtype=1
            if mi=1.0
                factor2(k)=trim(factor(mf))
            else
                factor2(k)=trim(factor(mf))+'^'+str(mi,4,1)
            endif
            factor3(k)=mi
        case mtype=2
            factor2(k)='EXP('+trim(factor(mf))+')'
            factor3(k)=-5
        case mtype=3
            factor2(k)='LOG('+trim(factor(mf))+')'
            factor3(k)=-10
        endcase
        factor1(k)=mf
    endif
endcase
clear read
@0,62 clear to 8,120

function factor_dele

```

```

if k>0
    for i=mf2 to k
        factor2(i)=factor2(i+1)
        factor1(i)=factor1(i+1)
    endfor
    factor2(k)=' '
    factor1(k)=0
    k=k-1
endif

function factor_t1
if mtype=1
    @5,63 GET mi SPINNER 0.2, 0, 99 ;
    PICTURE "@K" ;
    SIZE 0.846, 5.400 ;
    DEFAULT 1.0 ;
    FONT "MS Sans Serif", 8
@4.8,72.5 GET mchk ;
    PICTURE "@*HT \!\<OK" ;
    SIZE 1.2,6;
    DEFAULT 1 ;
    FONT "MS Sans Serif", 8

    read
    clear read
endif

function model_type
if idpt>0
@22,m1
if mmodel=1
    @22,m1 say 'a0'
    m11=col()
    for i=1 to k
        if i<9
            j=str(i,1)
        else
            j=str(i,2)
        endif
        @22,m11 say ' + a'+j+' x '+trim(factor2(i))
        m11=col()
    endfor
else
    @22,m1 say 'e' style 'B' FONT "MS Sans Serif", 11
    @22,m1+2 say "b0" font "Small Fonts", 5
    m11=col()
    for i=1 to k
        if i<9
            j=str(i,1)
        else
            j=str(i,2)
        endif
        @22,m11 say ' x ('+trim(factor2(i))+')'
        m11=col()
        @22,m11 say "b"+j font "Small Fonts", 5
        m11=col()
    endfor
endif
endif

procedure export_data
dimension data(nn,k+1),mmax(k+1)
sele 5
go top

```

```

i=0
for j=1 to k+1
    mmax(j)=0
endfor

scan
    i=i+1
    mdata= &factor(idpt)
    data(i,1)=mdata
    for j=1 to k
        l=factor1(j)
        mdata= &factor(l)
        do case
            case factor3(j)>0
                data(i,j+1)=mdata^factor3(j)
            case factor3(j)=-5
                data(i,j+1)=exp(mdata)
            case factor3(j)=-10
                if mdata<=0
                    i=i-1
                    loop
                else
                    data(i,j+1)=log(mdata)
                endif
            endcase
        endfor
        for j=1 to k+1
            if mmodel=2
                data(i,j)=log(data(i,j))
            endif
            if data(i,j)>mmax(j)
                mmax(j)=data(i,j)
            endif
        endfor
    endscan
    for j=1 to k+1
        mmax(j)=len(alltrim(str(int(mmax(j)),20)))+mdec+2
        if mmax(j)>20
            mmax(j)=20
        endif
    endfor

    sele 8
    set safe off
    copy stru to aaa1
    sele 7
    use aaal
    for j=1 to k+1
        if j<9
            jj=str(j,1)
        else
            jj=str(j,2)
        endif
        sele 7
        append blank
        repl field_name with 'data'+jj,field_type with 'N',;
            field_len with mmax(j),field_dec with mdec
    endfor
    use
    create aaa2 from aaa1
    use aaa2
    append from array data
    copy to aaa3 sdf

```

```

set safe on

procedure regress
use lm_mtb
if k<9
    j2=str(k,1)
else
    j2=str(k,2)
endif
j=k+1
if j<9
    j1=str(j,1)
else
    j1=str(j,2)
endif

repl mtb_comd with "read from '\fpw26\aaa3.txt' c1-c"+j1
go 3
if k>2
    repl mtb_comd with "regress c1 &j2 c2-c"+j1
else
    repl mtb_comd with "regress c1 1 c2"
endif
set safe off
copy to lm_mtb.mtb deli with BLANK
erase lm_rst.lis
set safe on
run lmsdss\lm_mtb

procedure display
dimension mcoeff(k+1),p_value(k+1)

IF WVISIBLE("lm_rgss1")
    ACTIVATE WINDOW lm_rgss1 SAME
ELSE
    ACTIVATE WINDOW lm_rgss1 NOSHOW
ENDIF

on key label f1 help p Regression Result

sele 3
use lm_rst
if file("lm_rst.lis")
dele all
pack
appe from lm_rst.lis sdf

clear
do while .t.

* Extract the model information
    sele 3
    loca for mtb_comd='C1 ='
    mtb=alltrim(mtb_comd)
    n=len(mtb)-5
    mtb=right(mtb,n)
    i=0
    do while .t.
        i=i+1
        m1=at(' ',mtb,i)
        if substr(mtb,m1+1,1)$'+-C'
            exit
        endif

```



```

        enddo
        mcoeff(1)=trim(substr(mtb,1,m1))
        mtb=substr(mtb,m1+1,n-m1)
        n=len(mtb)
        for i=1 to k
            m1=at('C',mtb)
            mcoeff(i+1)=substr(mtb,1,m1-1)
            if i<9
                m1=m1+2
            else
                m1=m1+3
            endif
            if n-m1>m1+1
                mtb=substr(mtb,m1+1,n-m1)
            endif
            n=len(mtb)
        endfor

* Extract the fitness information
    loca for mtb_comd='Constant'
        i=0
        scan while mtb_comd='C'
            i=i+1
            p_value(i)=right(trim(mtb_comd),6)
        endscan
        loca for mtb_comd='s ='
            mr=trim(mtb_comd)
            @2,40 say 'The regression model' font "Times New Roman", 16
style 'b'
            @5,2 say trim(factor(idpt))+ ' = '
            ml=col()
            if mmodel=1
                @5,m1 say mcoeff(1)+ ' '
            else
                @5,m1 say 'e' style 'B' FONT "MS Sans Serif", 11
                @5,m1+2 say mcoeff(1) font "Small Fonts", 5
            endif
            ml=col()
            for i=1 to k
                if mmodel=1
                    @5,m1 say mcoeff(i+1)+factor2(i)+ ' '
                else
                    @5,m1 say '('+factor2(i)+')'
                    ml=col()
                    @5,m1 say mcoeff(i+1) font "Small Fonts", 5
                endif
                ml=col()
            endfor

* Extract signifance information
    @8,40 say 'P - Value' font "Times New Roman", 14 style 'b'
    @11,2 say 'Constant'
    ml=col()
    ml=ml
    @13,1 say p_value(1)
    for i=1 to k
        @11,m1+3 say factor2(i)
        ml=col()
        @13,m1+2 say p_value(i+1)
        ml=ml
    endfor
    @16,40 say "The model's fitness" font "Times New Roman", 14
style 'b'

```

```

@19,30 say mr
@25,30 GET mdis ;
    PICTURE "@*HT \<Detail;\<Residual;\<Accept;\?\<Quit" ;
    SIZE 1.769,8.667,1.333 ;
    DEFAULT 1 ;
    FONT "MS Sans Serif", 8 ;
    STYLE "B"

read
do case
case mdis=1
    browse noedit noappend nodelete nomenu window lm_rgssl
case mdis=3
    clear
    @2,20 say "The model you selected is as follows." font
"Times New Roman", 14 style 'b'
    @4,20 say "Do you accept it and use it as the " font
"Times New Roman", 14 style 'b'
    @6,20 say "new depot turnover prediction model?" font
"Times New Roman", 14 style 'b'
    r=10
    @r,0 say trim(factor(idpt))+ ' = '
    ml=col()
    if mmodel=1
        @r,ml say mcoeff(1)+' '
    else
        @r,ml say 'e' style 'B' FONT "MS Sans Serif", 11
        @r,ml+2 say mcoeff(1) font "Small Fonts", 5
    endif
    ml=col()
    for i=1 to k
        if mmodel=1
            @r,ml say mcoeff(i+1)+factor2(i)+' '
        else
            @r,ml say '('+factor2(i)+')'
            ml=col()
            @r,ml say mcoeff(i+1) font "Small Fonts", 5
        endif
        ml=col()
    endfor
    @ 25,76 GET mck ;
    PICTURE "@*HT \<OK;\?\<Cancel" ;
    SIZE 1.769,8.667,1.333 ;
    DEFAULT 2 ;
    FONT "MS Sans Serif", 8 ;
    STYLE "B"

read
if mck=1
    mm='m'+trim(factor(idpt))+ '='
    if mmodel=1
        mm=mm+mcoeff(1)
    else
        mm=mm+'exp('+mcoeff(1)+')'
    endif
    for i=1 to k
        if mmodel=1
            mm=mm+mcoeff(i+1)+'*m'+factor2(i)
        else
            mm=mm+'*(m'+factor2(i)+')^('+mcoeff(i+1)+')'
        endif
    endfor
    use lm_model
    skip

```

```

        repl model with 'mweight='+alltrim(mweight)
        skip
        repl model with mm
        set safe off
        copy to lmsdss\lm_turn.prg deli with BLANK
        set safe on
    endif
    clear
    case mdis=2
*      mm='m'+trim(factor(idpt))+ '='
      mm='mfoct='
      if mmodel=1
          mm=mm+mcoeff(1)
      else
          mm=mm+'exp('+mcoeff(1)+')'
      endif
      for i=1 to k
          if mmodel=1
              mm=mm+mcoeff(i+1)+'*'+factor2(i)
          else
              mm=mm+'*('+factor2(i)+')^('+mcoeff(i+1)+')'
          endif
      endfor
      do lm_foct with mm
    case mdis=4
        exit
    endcase
enddo
else
@10,20 say "The regrssion analysis failed - can't find file
LM_RST.LIS" ;
    FONT "MS Sans Serif", 10 ;
    STYLE "B"
@ 25,60 GET mck ;
    PICTURE "@*HT \<OK" ;
    SIZE 1.769,8.667,1.333 ;
    DEFAULT 1 ;
    FONT "MS Sans Serif", 8 ;
    STYLE "B"
read
endif

```

```

*          *****
*          *
*          * 13/02/95                LM_RGSS.PRG                14:48:38
*          *
*          *****
*          *
*          * Author's Name: Xiaoyong Tao
*          *
*          * Copyright (c) 1994 Company Name
*          * Address
*          * City,      Zip
*          *
*          * Description:
*          * Provide the Windows interface for the regression analysis
*          * using a stactstcis package (MINITAB)
*          *
*          *****

set path to lmsdss
*set stat off
public mturn,mturn1,mfact,mfact1,mchange1,mchange2,mper1,mper2,mfacto
public mcptn(30),mcpts(30),mcptd(30)
public msize__sq_f,mprice_comp,mcarl,mincome,mdwcs,n
public m.size__sq_f,m.price_comp,m.carl,m.income,mdwcs1,mcond
sp=space(30)
ms1=''
ms2=''
set talk off
close database
sele 4
use lm_cacil
sele distinct postcode from lm_cacil into array c_post1
sele 9
use lm_compl
sele 1
use lm_dept index lm_deftp
sele distinct depot from lm_dept into array c_depot
sele distinct post_code from lm_dept into array c_post
mdwcs=1
mdwct=1

on key label fl help p Analysis

IF NOT WEXIST("lmanall")
    DEFINE WINDOW lmanall ;
        AT 0.000, 0.000 ;
        SIZE 31.538,126.800 ;
        title "Landmark Depot Performance Analysis" ;
        FONT "MS Sans Serif", 8 ;
        FLOAT ;
        NOCLOSE ;
        MINIMIZE ;
        SYSTEM
ENDIF

do while .t.
*      clear

        for i=1 to 30
            mcptn(i)=sp
            mcpts(i)=0
            mcptd(i)=0
        endfor

```

```

IF NOT WVISIBLE("lmanall")
    ACTIVATE WINDOW lmanall
ENDIF

@ 3.692,76.400 GET menquiry ;
    PICTURE "@^T \<Depot Name;\<Post Code" ;
    SIZE 1.538,18.333 ;
    DEFAULT "Depot Name" ;
    FONT "MS Sans Serif", 8 ;
    STYLE "B"

@1,0 clear to 26,70
do case
case menquiry="Depot Name"
    @5.692,16.400 get msearch from c_depot size 16,32 ;
        FONT "MS Sans Serif", 8 ;
        STYLE "B" defa c_depot(1) when refresh()

case menquiry="Post Code"
    @5.692,16.400 get msearch from c_post size 16,32 ;
        FONT "MS Sans Serif", 8 ;
        STYLE "B" defa c_post(1) when refresh()
endcase

@ 3.292,16.400 to 4.992,54.400 double
@ 3.692,17.400 GET msearch ;
    SIZE 1,30 pict "@!" ;
    FONT "MS Sans Serif", 8 ;
    STYLE "BT"

mcheck=3

@ 19.615,76.800 GET mcheck ;
    PICTURE "@*HT \!\<OK;\?\<Quit" ;
    SIZE 1.769,8.667,1.333 ;
    DEFAULT 3 ;
    FONT "MS Sans Serif", 8 ;
    STYLE "B"

READ CYCLE

do case
case mcheck=2
    exit
case mcheck>2
    loop
endcase

do case
case menquiry="Depot Name"
    msel3=0
    mdd=trim(msearch)
    mdd=upper(mdd)
    sele 1
    locate for mdd$depot
    mcond="mdd$depot"
    do display2

case menquiry="Post Code"
    msel3=0
    mdd=trim(msearch)
    mdd=upper(mdd)

```

```

        sele 1
        locate for mdd$post_code
        mcond="mdd$post_code"
        do display2
    endcase

enddo

release window lmanal1
return

procedure display2

*          *****
*          *
*          *          Windows Window definitions
*          *
*          *****
*

on key label f1 help Depot Performance Analysis

IF NOT WEXIST("lmanal2")
    DEFINE WINDOW lmanal2 ;
        AT 0.000, 0.000 ;
        SIZE 31.538,126.800 ;
        title "Landmark Depot Performance Analysis" ;
        FONT "MS Sans Serif", 8 ;
        FLOAT ;
        NOCLOSE ;
        MINIMIZE ;
        SYSTEM
ENDIF

*          *****
*          *
*          *          LM_DTQ1/Windows Screen Layout
*          *
*          *****
*

#REGION 1
IF WVISIBLE("lmanal2")
    ACTIVATE WINDOW lmanal2 SAME
ELSE
    ACTIVATE WINDOW lmanal2 NOSHOW
ENDIF

do while &mcond
    clear
    mrst=0
    sele 1
    scatter memvar

    mdepot1=m.depot
    mdepot=m.depot
    mpost_code=m.post_code
    mlocation=m.location
    mcounty=m.county
    mturnoverxx=m.turnoverxx
    msize__sq_f=m.size__sq_f

```

```

mdepot_rank=m.depot_rank
mprice_comp=m.price_comp
memployee=m.employee
mrec=recn()

mpd=post_code+trim(depot)
sele 4
if len(msl)<1
    locate for postcode=m.post_code
else
    loca for postcode=msearchp
    mpd=msearchp
endif
scatter memvar
mpopu=m.popu
mactw=m.actw
mcarl=m.carl
mpens=m.pens
mincome=m.income

mpd=substr(mpost_code,1,6)
sele 9
locate for postcode=mpd .and. dist=0
if eof()
    n=0
else
    i=0
    do while .t.
        if dist<999.9
            mmpost=postcode
            mdist=dist
            sele 1
            seek mmpost
            do while post_code=mmpost
                if recn()<>mrec
                    i=i+1
                    mcptn(i)=depot
                    mcpts(i)=size__sq_f
                    mcptd(i)=mdist
                    if i=30
                        exit
                    endif
                endif
            skip
            enddo
            if i=30
                exit
            endif
            sele 9
        endif
        skip
        if dist<0.1
            exit
        endif
    enddo
    n=i
endif
if n<30
    for i=n+1 to 30
        mcptn(i)=sp
        mcpts(i)=0
        mcptd(i)=0
    endfor

```

```

endif
sele 1
go mrec

do analysis
msize=msize__sq_f
mcomp=mprice_comp
mrnk=mdepot_rank
memploy=memployee
m.popu=mpopu
m.carl=mcarl
m.income=mincome
m.actw=mactw
m.pens=mpens
mdwcs=mdwcs1
mturn=mturn1
* clear
do result

do while .t.

* Depot Characteristics

@ 0.077,0.000 SAY "Depot" ;
  FONT "MS Sans Serif", 8 ;
  STYLE "BT"
@ 1.000,0.000 SAY "Location" ;
  FONT "MS Sans Serif", 8 ;
  STYLE "BT"
@ 1.000,50.400 SAY "County" ;
  FONT "MS Sans Serif", 8 ;
  STYLE "BT"
@ 0.077,50.400 SAY "Post code" ;
  FONT "MS Sans Serif", 8 ;
  STYLE "BT"
@ 0.077,80.800 SAY "Group" ;
  FONT "MS Sans Serif", 8 ;
  STYLE "BT"
@ 2.231,0.000 SAY "Turnover" ;
  FONT "MS Sans Serif", 8 ;
  STYLE "BT"
@ 2.231,26.400 SAY "Size" ;
  FONT "MS Sans Serif", 8 ;
  STYLE "BT"
@ 2.231,50.400 SAY "DepotRank" ;
  FONT "MS Sans Serif", 8 ;
  STYLE "BT"
@ 2.231,67.000 SAY "PriceComp" ;
  FONT "MS Sans Serif", 8 ;
  STYLE "BT"
@ 2.231,87.8 SAY "Employee" ;
  FONT "MS Sans Serif", 8 ;
  STYLE "BT"
@ 0.077,14.800 SAY mdepot ;
  SIZE 1.000,33.800 ;
  FONT "MS Sans Serif", 8
@ 1.154,14.800 SAY m.location ;
  SIZE 1.000,26.800 ;
  FONT "MS Sans Serif", 8
@ 1.154,65.200 SAY m.county ;
  SIZE 1.000,30.000 ;
  FONT "MS Sans Serif", 8
@ 0.077,65.200 SAY m.post_code ;

```



```

        SIZE 1.000,13.600 ;
        FONT "MS Sans Serif", 8
@ 0.077,90.600 SAY m.groupn ;
        SIZE 1.000,13.600 ;
        FONT "MS Sans Serif", 8
@ 2.231,14.800 say mturnoverxx ;
        SIZE 1.000,7.400 ;
        FONT "MS Sans Serif", 8
@ 2.231,37.000 get msize__sq_f ;
        SIZE 1.000,10.200 ;
        FONT "MS Sans Serif", 8
@ 2.231,63.200 get mdepot_rank ;
        SIZE 1.000,2.800 ;
        FONT "MS Sans Serif", 8
@ 2.231,83 get mprice_comp ;
        SIZE 1.000,2.800 ;
        FONT "MS Sans Serif", 8
@ 2.231,100 get memployee ;
        SIZE 1.000,6.200 ;
        FONT "MS Sans Serif", 8

```

*Catchment Demographics

```

@ 3.308,0.000 SAY "Population" ;
        FONT "MS Sans Serif", 8 ;
        STYLE "BT"
@ 3.308,50.000 SAY "%Carless" ;
        FONT "MS Sans Serif", 8 ;
        STYLE "BT"
@ 3.308,26.400 SAY "Act.Women" ;
        FONT "MS Sans Serif", 8 ;
        STYLE "BT"
@ 3.308,67.200 SAY "Income" ;
        FONT "MS Sans Serif", 8 ;
        STYLE "BT"
@ 3.308,87.800 SAY "%OAP" ;
        FONT "MS Sans Serif", 8 ;
        STYLE "BT"
@ 3.308,12.400 get mpopu ;
        SIZE 1.000,11.200 ;
        FONT "MS Sans Serif", 8
@ 3.308,41.200 get mactw ;
        SIZE 1.000,6.000 ;
        FONT "MS Sans Serif", 8
@ 3.308,60.400 get mcarl ;
        SIZE 1.000,6.000 ;
        FONT "MS Sans Serif", 8
@ 3.308,77.200 get mincome ;
        SIZE 1.000,8.800 ;
        FONT "MS Sans Serif", 8
@ 3.308,100.400 get mpens ;
        SIZE 1.000,6.000 ;
        FONT "MS Sans Serif", 8

```

* Competitors

```

@ 5.462,4.800 SAY "Competitors in the Catchment Area" ;
        FONT "MS Sans Serif", 10 ;
        STYLE "BT"
@ 7.462,7.200 SAY "Competitor Name" ;
        FONT "MS Sans Serif", 8 ;
        STYLE "BT"
@ 7.462,33.600 SAY "Size" ;

```

```

        FONT "MS Sans Serif", 8 ;
        STYLE "BT"
@ 7.462,40.800 SAY "Distance" ;
        FONT "MS Sans Serif", 8 ;
        STYLE "BT"
if n>0
    xx=1.000
    x=9.308
    for i=1 to n
        @ x,0.400 say mcptn(i) ;
            SIZE 1.000,28.000 ;
            FONT "MS Sans Serif", 8
        @ x,31.600 get mcpts(i) ;
            SIZE 1.000,8.800 ;
            FONT "MS Sans Serif", 8
        @ x,43.600 say mcptd(i) ;
            SIZE 1.000,6.000 ;
            FONT "MS Sans Serif", 8
        if i<20
            x=x+xx
        endif
    endfor
endif

if len(ms1)>1
    @7,70 say ms1 style 'B'
    @8,70 say ms2 style 'B'
endif

sele 1
mrec=recn()
do while .not. eof()
    skip
    if &mcond
        exit
    endif
enddo
if eof()
    mnext='\\\<Next;'
else
    mnext='\<Next;'
endif
go mrec
do while .not. bof()
    skip -1
    if &mcond
        exit
    endif
enddo
if bof()
    mprev='\\\<Previous;'
else
    mprev='\<Previous;'
endif
go mrec

sele 4
if eof()
    @8,60 clear to 25,100
    manal='\\\<Analysis'
    @8,70 say 'No catchment area ' style 'B'
    @9,70 say 'information for above depot' style 'B'
    @10,70 get msearchp from c_post1 size 17,20 ;

```

```

        function '&T' ;
        FONT "MS Sans Serif", 8 ;
        STYLE "B" defa c_post(1) when refresh1()
    else
        manal='\<Analysis'
        msl=''
    endif

    m.choice=3
    @ 0.000,110.200 GET m.choice ;
    PICTURE "@*VT
\<Add;" +manal+" ;\<Restore;" +mnext+mprev+"\?E\<xit" ;
    SIZE 1.769,10.333,0.308 ;
    DEFAULT 3 ;
    FONT "MS Sans Serif", 8 ;
    STYLE "B"

    read cycle

    mrst=10

    do case
    case m.choice=1
*       x=x+xx
        n=n+1
        @ x,0.400 get mcptn(n) ;
        SIZE 1.000,28.000 ;
        FONT "MS Sans Serif", 8
        @ x,31.600 get mcpts(n) ;
        pict "9999999" ;
        SIZE 1.000,8.800 ;
        FONT "MS Sans Serif", 8
        @ x,43.600 get mcptd(n) ;
        pict "99.9" ;
        SIZE 1.000,6.000 ;
        FONT "MS Sans Serif", 8
*       read cycle
        loop
    case m.choice=2
        do analysis
        do case
        case msize__sq_f<>msize
            mfact=msize
            mfact1=msize__sq_f
            mfactc=1
        case mdepot_rank<>mrnk
            mfact=mrnk
            mfact1=mdepot_rank
            mfactc=2
        case mprice_comp<>mcomp
            mfact=mcomp
            mfact1=mprice_comp
            mfactc=3
        case mpopu<>m.papu
            mfact=m.papu
            mfact1=mpapu
            mfactc=4
        case mincome<>m.income
            mfact=m.income
            mfact1=mincome
            mfactc=5
        case mcarl<>m.carl
            mfact=m.carl

```

```

        mfact1=mcarl
        mfactc=6
    case mactw<>m.actw
        mfact=m.actw
        mfact1=mactw
        mfactc=7
    case mpens<>m.pens
        mfact=m.pens
        mfact1=mpens
        mfactc=8
    case mdwcs1<>mdwcs
        mfact=mdwcs
        mfact1=mdwcs1
        mfactc=9
    case memployee<>memploy
        mfact=memploy
        mfact1=memployee
        mfactc=10
    other
        mfact1=1
        mfact=mfact1
        mfactc=0
    endcase
    mchange1=mturn1-mturn
    mper1=mchange1/mturn*100
    mchange2=mfact1-mfact
    mper2=mchange2/mfact*100
    do result
        msize=msize__sq_f
        mcomp=mprice_comp
        mrank=mdepot_rank
        memploy=memployee
        m.popu=mpopu
        m.carl=mcarl
        m.actw=mactw
        m.income=mincome
        m.pens=mpens
        mdwcs=mdwcs1
        mturn=mturn1
    case m.choice>2
        exit
    endcase
enddo
do case
case m.choice=3
    sele 1
    loop
case m.choice=4
    sele 1
    do while .not. eof()
        skip
        if &mcond
            exit
        endif
    enddo
case m.choice=5
    sele 1
    do while .not. bof()
        skip -1
        if &mcond
            exit
        endif
    enddo
enddo

```

```

        case m.choice=6
            exit
        endcase
    enddo

clear

*release window _qq915v0se
release window lmanal2

return

procedure analysis

mweight=0

do lm_turn with ;
    mturn1,msize__sq_f,mdepot_rank,mprice_comp,memployee,mpopu,minco
me,;
    mactw,mcarl,mpens,mdwcs,mdwct,mweight    && read the distance
weight

mdwcs1=1
for i=1 to n
    if mcptd(i)>0
        mdwcs1=mdwcs1+mcpts(i)/mcptd(i)^mweight
    endif
endfor

*mturn1=exp(-
23.5)*msize__sq_f^0.661*mprice_comp^0.659*mcarl^0.956*mincome^1.57/mdw
cs1^0.026

do lm_turn with ;
    mturn1,msize__sq_f,mdepot_rank,mprice_comp,memployee,mpopu,minco
me,;
    mactw,mcarl,mpens,mdwcs1,mdwct,mweight

return

procedure result

@8,0 clear

@ 9.923,69.600 SAY "Analysis Result" ;
    FONT "MS Sans Serif", 12 ;
    STYLE "BT"
@ 12.154,64.800 SAY "Turnover" ;
    FONT "MS Sans Serif", 8 ;
    STYLE "BT"
@ 14.000,60.400 SAY mturn1 ;
    pict "99.99" ;
    SIZE 1.000,6.400 ;
    FONT "MS Sans Serif", 8
if mrst>5
    yy=max(mturn1,mturn)
    yl=mturn/yy*10
    y2=mturn1/yy*10
    yy=max(mfact1,mfact)
    y3=mfact/yy*10
    y4=mfact1/yy*10
@ 13.000,53.800 SAY "Prev New Change    % " ;

```

```

        FONT "MS Sans Serif", 8 ;
        STYLE "BT"
@ 13.000,81.600 SAY "Previous    New    Change    %" ;
        FONT "MS Sans Serif", 8 ;
        STYLE "BT"
do case
case mfactc=1
    @ 12.154,91.200 SAY 'Depot Size' ;
        FONT "MS Sans Serif", 8 ;
        STYLE "BT"
    @ 14.000,82.000 SAY mfact ;
        pict "9999999" ;
        SIZE 1.000,8.400 ;
        FONT "MS Sans Serif", 8
    @ 14.000,91.600 SAY mfact1 ;
        SIZE 1.000,8.400 ;
        pict "9999999" ;
        FONT "MS Sans Serif", 8
    @ 14.000,101.200 SAY mchange2 ;
        pict "9999999" ;
        SIZE 1.000,8.400 ;
        FONT "MS Sans Serif", 8
case mfactc=2
    @ 12.154,91.200 SAY 'Depot Rank' ;
        FONT "MS Sans Serif", 8 ;
        STYLE "BT"
    @ 14.000,82.000 SAY mfact ;
        pict "9999" ;
        SIZE 1.000,7.400 ;
        FONT "MS Sans Serif", 8
    @ 14.000,91.600 SAY mfact1 ;
        pict "9999" ;
        SIZE 1.000,7.400 ;
        FONT "MS Sans Serif", 8
    @ 14.000,101.200 SAY mchange2 ;
        pict "9999" ;
        SIZE 1.000,8.400 ;
        FONT "MS Sans Serif", 8
case mfactc=3
    @ 12.154,91.200 SAY 'Price Comp' ;
        FONT "MS Sans Serif", 8 ;
        STYLE "BT"
    @ 14.000,82.000 SAY mfact ;
        pict "9999" ;
        SIZE 1.000,7.400 ;
        FONT "MS Sans Serif", 8
    @ 14.000,91.600 SAY mfact1 ;
        pict "9999" ;
        SIZE 1.000,7.400 ;
        FONT "MS Sans Serif", 8
    @ 14.000,101.200 SAY mchange2 ;
        pict "9999" ;
        SIZE 1.000,8.400 ;
        FONT "MS Sans Serif", 8
case mfactc=4
    @ 12.154,91.200 SAY 'Population' ;
        FONT "MS Sans Serif", 8 ;
        STYLE "BT"
    @ 14.000,82.000 SAY mfact ;
        pict "9999999" ;
        SIZE 1.000,9.400 ;
        FONT "MS Sans Serif", 8
    @ 14.000,91.600 SAY mfact1 ;

```

```

        SIZE 1.000,9.400 ;
        pict "9999999" ;
        FONT "MS Sans Serif", 8
@ 14.000,101.200 SAY mchange2 ;
        pict "99999999" ;
        SIZE 1.000,10.400 ;
        FONT "MS Sans Serif", 8
case mfactc=5
@ 12.154,91.200 SAY 'Ave. Income' ;
        FONT "MS Sans Serif", 8 ;
        STYLE "BT"
@ 14.000,82.000 SAY mfact ;
        pict "9999999" ;
        SIZE 1.000,7.400 ;
        FONT "MS Sans Serif", 8
@ 14.000,91.600 SAY mfact1 ;
        pict "9999999" ;
        SIZE 1.000,7.400 ;
        FONT "MS Sans Serif", 8
@ 14.000,101.200 SAY mchange2 ;
        pict "9999999" ;
        SIZE 1.000,8.400 ;
        FONT "MS Sans Serif", 8
case mfactc=6
@ 12.154,91.200 SAY 'Carless' ;
        FONT "MS Sans Serif", 8 ;
        STYLE "BT"
@ 14.000,82.000 SAY mfact ;
        pict "999.99" ;
        SIZE 1.000,7.400 ;
        FONT "MS Sans Serif", 8
@ 14.000,91.600 SAY mfact1 ;
        pict "999.99" ;
        SIZE 1.000,7.400 ;
        FONT "MS Sans Serif", 8
@ 14.000,101.200 SAY mchange2 ;
        pict "999.99" ;
        SIZE 1.000,8.400 ;
        FONT "MS Sans Serif", 8
case mfactc=7
@ 12.154,91.200 SAY 'Actwomen' ;
        FONT "MS Sans Serif", 8 ;
        STYLE "BT"
@ 14.000,82.000 SAY mfact ;
        pict "999.99" ;
        SIZE 1.000,7.400 ;
        FONT "MS Sans Serif", 8
@ 14.000,91.600 SAY mfact1 ;
        pict "999.99" ;
        SIZE 1.000,7.400 ;
        FONT "MS Sans Serif", 8
@ 14.000,101.200 SAY mchange2 ;
        pict "999.99" ;
        SIZE 1.000,8.400 ;
        FONT "MS Sans Serif", 8
case mfactc=8
@ 12.154,91.200 SAY 'O. A. P.' ;
        FONT "MS Sans Serif", 8 ;
        STYLE "BT"
@ 14.000,82.000 SAY mfact ;
        pict "999.99" ;
        SIZE 1.000,7.400 ;
        FONT "MS Sans Serif", 8

```

```

@ 14.000,91.600 SAY mfact1 ;
    pict "999.99" ;
    SIZE 1.000,7.400 ;
    FONT "MS Sans Serif", 8
@ 14.000,101.200 SAY mchange2 ;
    pict "999.99" ;
    SIZE 1.000,8.400 ;
    FONT "MS Sans Serif", 8
case mfactc=9
@ 12.154,88.200 SAY 'Competitor DWCS' ;
    FONT "MS Sans Serif", 8 ;
    STYLE "BT"
@ 14.000,82.000 SAY mfact ;
    pict "99999999" ;
    SIZE 1.000,8.400 ;
    FONT "MS Sans Serif", 8
@ 14.000,91.600 SAY mfact1 ;
    pict "99999999" ;
    SIZE 1.000,8.400 ;
    FONT "MS Sans Serif", 8
@ 14.000,101.200 SAY mchange2 ;
    pict "99999999" ;
    SIZE 1.000,8.400 ;
    FONT "MS Sans Serif", 8
case mfactc=10
@ 12.154,91.200 SAY 'Employee' ;
    FONT "MS Sans Serif", 8 ;
    STYLE "BT"
@ 14.000,82.000 SAY mfact ;
    pict "99999999" ;
    SIZE 1.000,8.400 ;
    FONT "MS Sans Serif", 8
@ 14.000,91.600 SAY mfact1 ;
    SIZE 1.000,8.400 ;
    pict "99999999" ;
    FONT "MS Sans Serif", 8
@ 14.000,101.200 SAY mchange2 ;
    pict "99999999" ;
    SIZE 1.000,8.400 ;
    FONT "MS Sans Serif", 8
other
@ 12.154,91.200 SAY 'No Change' ;
    FONT "MS Sans Serif", 8 ;
    STYLE "BT"
endcase
@ 14.077,53.200 SAY mturn ;
    pict "99.99" ;
    FONT "MS Sans Serif", 8
@ 14.000,68.600 SAY mchange1 ;
    pict "99.99" ;
    FONT "MS Sans Serif", 8
@ 14.000,74.000 SAY mper1 ;
    pict "999.9" ;
    FONT "MS Sans Serif", 8
@ 14.077,112.800 SAY mper2 ;
    pict '999.9' ;
    FONT "MS Sans Serif", 8
@ 25-y1,54.400 fill to 25,59.400 color w/g
@ 25-y2,62.400 fill to 25,67.400 color w/r
@ 25-y3,83.400 fill to 25,88.400 fill color w/g
@ 25-y4,92.400 fill to 25,97.400 color w/r

endif

```



```
function refresh
@3.692,17.400 say space(60)
@ 3.692,17.400 say msearch ;
    SIZE 1,30 pict "@" ;
    FONT "MS Sans Serif", 8 ;
    STYLE "BT"
```

```
function refresh1
loca for postcode=msearchp
*mpd=msearchp
ms1='Using the demographic'
ms2='info of area '+msearchp
```

```

*          *****
*          *
*          * 27/06/94          LM_fore.PRG          14:47:35
*          *
*          *****
*          *
*          * Author's Name
*          *
*          * Copyright (c) 1994 Company Name
*          * Address
*          * City,          Zip
*          *
*          * Description:
*          * This program was automatically generated by GENSCRN.
*          *
*          *****

*          *****
*          *
*          *          Windows Window definitions
*          *
*          *****
*
sele 1
use lm_dept index lm_deftp
sele 9
use lm_compl
sele 4
use lm_cacil
sele distinct substr(postcode,1,6) from lm_cacil into array c_post

on key label f1 help p Predict

IF NOT WEXIST("lm_fore")
    DEFINE WINDOW lm_fore ;
        AT 0.000, 0.000 ;
        SIZE 30.900,126.800 ;
        FONT "MS Sans Serif", 8 ;
        title "Prediction" ;
        FLOAT ;
        NOCLOSE ;
        MINIMIZE ;
        SYSTEM
ENDIF

*          *****
*          *
*          *          AA/Windows Screen Layout
*          *
*          *****
*

IF WVISIBLE("lm_fore")
    ACTIVATE WINDOW lm_fore SAME
ELSE
    ACTIVATE WINDOW lm_fore NOSHOW
ENDIF

dimension mcomp(28),mdist(28)
mdimen=28
for i=1 to mdimen

```

```

        mcomp(i)=0
        mdist(i)=99.99
    endfor
    store 0 to msize,mprice,mrank,memploy,mpopu,mactw,mpens,mincome,mturn
    mcarl=0.00
    *minit=0
    *do initiate
    nsearch='*****'
    ii=0

    do while .t.

        @2,26 say 'Depot Turnover Prediction' font 'Times New roman',18
    ;
        style 'BT'
        @6.5,90 say 'Catchment Area' font 'Times New roman',12 ;
        style 'BT'
        @8,90 get msearch from c_post size 17,20 ;
        FONT "MS Sans Serif", 8 ;
        STYLE "B" defa c_post(1) valid refresh()

        @4,10 say 'Depot Size: ' get msize pict '9999999' size 1,8
        @4,35 say 'Depot Rank: ' get mrank pict '99' range 1,9
        @4,60 say 'Price Comp: ' get mprice pict '99' range 1,9
        @4,80 say 'Employee: ' get memploy pict '9999' size 1,6
        @5.5,10 say 'Population: ' get mpopu pict '9999999' size 1,10
        @5.5,60 say 'Ave. Income: ' get mincome pict '999999' size 1,8
        @7,10 say '% ActWomen : ' get mactw pict '99.99' size 1,6
        @7,35 say '% Carless : ' get mcarl pict '99.99' size 1,6
        @7,60 say '% O.A.P. : ' get mpens pict '99.99' size 1,6
        @9,24 say 'Competitors in the Catchment Area' font 'Times New
roman',14 ;
        style 'BT'
        k=0
        @11,16 say '      Size      Dist      Size      Dist      Size'+;
        '      Dist      Size      Dist' style 'B'
        r=12.5
        l=-2
        for i=1 to mdimen
            if k>3
                k=0
                r=r+1.2
                l=16
            else
                l=l+18
            endif
            @r,l get mcomp(i) pict '9999999' size 1,8
            @r,l+10 get mdist(i) pict '99.99' size 1,6
            k=k+1
        endfor

        mcheck=3
        @ 24.015,40.400 GET mcheck ;
        PICTURE "@*HT \\!<OK;<Initiate;\\?<Quit" ;
        SIZE 1.769,8.667,1.333 ;
        DEFAULT 3 ;
        FONT "MS Sans Serif", 8 ;
        STYLE "B"

    READ CYCLE

    do case
    case mcheck=2

```

```

do initiate
loop
case mcheck=3
exit
endcase

n=0
mdwcs=1
mdwct=1
mweight=0
do lm_turn with ;
    mturn,msize,mrank,mprice,memploy,mpopu,mincome,;
    mactw,mcarl,mpens,mdwcs,mdwct,mweight    && read the
distance weight
    for i=1 to mdimen
        if mdist(i)<99 .and. mdist(i)>0
            mdwcs=mdwcs+mcomp(i)/mdist(i)^mweight
            n=n+1
        endif
    endfor
do lm_turn with ;
    mturn,msize,mrank,mprice,memploy,mpopu,mincome,;
    mactw,mcarl,mpens,mdwcs,mdwct,mweight
@22,24 say 'The predicted turnover='+str(mturn,6,2) ;
font 'Courier',14 style 'B'

enddo

RELEASE WINDOW lm_fore

return

procedure initiate
@12,0 clear to 23.5,110
k=0
r=12.5
l=-2
for i=1 to ii
    if k>3
        k=0
        r=r+1.2
        l=16
    else
        l=l+18
    endif
    @r,l say mcomp(i) pict '9999999' size 1,8
    @r,l+10 say mdist(i) pict '99.99' size 1,6
    k=k+1
endfor

for i=1 to mdimen
    mcomp(i)=0
    mdist(i)=99.99
endfor
store 0 to msize,mprice,mrank,memploy

function refresh
sele 4
loca for postcode=msearch
mpopu=popu
mactw=actw
mcarl=carl
mpens=pens

```

```

mincome=income

i=0
sele 9
locate for postcode=msearch .and. dist=0
do while .t.
    if dist<999.99
        mmpost=postcode
        mmdist=dist
        sele 1
        seek mmpost
        do while post_code=mmpost
            i=i+1
            mcomp(i)=size__sq_f
            mdist(i)=mmdist
            if i=mdimen
                exit
            endif
            skip
        enddo
        if i=mdimen
            exit
        endif
        sele 9
    endif
    skip
    if dist<0.1
        exit
    endif
enddo

if i<mdimen
    ii=i
    for i=ii+1 to mdimen
        mcomp(i)=0
        mdist(i)=99.99
    endfor
endif

if msearch<>nsearch
    @5.5,21.8 say mpopu pict '9999999' size 1,10
    @5.5,73.2 say mincome pict '999999' size 1,8
    @7,24.7 say mactw pict '99.99' size 1,6
    @7,46.4 say mcarl pict '99.99' size 1,6
    @7,71.4 say mpens pict '99.99' size 1,6
    @12,0 clear to 21,110
    k=0
    r=12.5
    l=-2
    for i=1 to ii
        if k>3
            k=0
            r=r+1.2
            l=16
        else
            l=l+18
        endif
        @r,l say mcomp(i) pict '9999999' size 1,8
        @r,l+10 say mdist(i) pict '99.99' size 1,6
        k=k+1
    endfor
endif
nsearch=msearch

```



```

*      *
*      *****
*
IF NOT WEXIST("lm_rsd1")
    DEFINE WINDOW lm_rsd1 ;
        AT 0.000, 0.000 ;
        SIZE 30.923,126.800 ;
        FONT "MS Sans Serif", 8 ;
        title "Residual Analysis "+mmsg ;
        FLOAT ;
        NOCLOSE ;
        MINIMIZE ;
        SYSTEM
ENDIF

IF NOT WEXIST("lm_plot")
    DEFINE WINDOW lm_plot ;
        AT 0.000, 0.000 ;
        SIZE 30.923,126.800 ;
        FONT "MS Sans Serif", 8 ;
        title "Residual Analysis "+mmsg ;
        FLOAT ;
        NOCLOSE ;
        MINIMIZE ;
        SYSTEM
ENDIF

*      *****
*      *
*      *              LM_rsd1/Windows Screen Layout
*      *
*      *****
*

#REGION 1
IF WVISIBLE("lm_rsd1")
    ACTIVATE WINDOW lm_rsd1 SAME
ELSE
    ACTIVATE WINDOW lm_rsd1 NOSHOW
ENDIF

on key label f1 help p Residual

msearch1=1
do while .t.

    @ 5.692,76.400 GET menquiry ;
        PICTURE "@^T Residual P\<lot;Residual P\<ercentage" ;
        SIZE 1.538,24.333 ;
        DEFAULT "Residual Plot" ;
        FONT "MS Sans Serif", 8 ;
        STYLE "B"

    do case
    case menquiry="Residual Plot"

        @5.692,16.400 get msearch from c_plot size 16,32 ;
        FONT "MS Sans Serif", 8 ;
        STYLE "B" defa c_plot(1) when refresh1()

    case menquiry='Residual Percentage'

```



```

        @5.692,16.4 clear to 25,66
        do res_per
    endcase

    @ 19.615,76.800 GET mchk ;
        PICTURE "@*HT \? \<Quit" ;
        SIZE 1.769,8.667,1.333 ;
        DEFAULT 3 ;
        FONT "MS Sans Serif", 8 ;
        STYLE "B"

    READ CYCLE

    IF NOT WVISIBLE("lm_rsdl")
        ACTIVATE WINDOW lm_rsdl
    ENDIF

    if mchk=1
        exit
    endif

enddo

release windows lm_rsdl

function Refresh1
sele 9
mrec=reccount()

IF NOT WEXIST("lm_plot")
    DEFINE WINDOW lm_plot ;
        AT 0.000, 0.000 ;
        SIZE 30.923,126.800 ;
        FONT "MS Sans Serif", 8 ;
        title "Residual Plot "+mmmsg ;
        FLOAT ;
        NOCLOSE ;
        MINIMIZE ;
        SYSTEM
ENDIF
do case
case msearch='Depot Size'
    mfield='size'
case msearch='Depot Rank'
    mfield='rank'
case msearch='Price Competitiveness'
    mfield='comp'
case msearch='Catchment Population'
    mfield='popu'
case msearch='Household Income'
    mfield='incm'
case msearch='% Active Women'
    mfield='actw'
case msearch='% Carless Households'
    mfield='carl'
case msearch='% Old Aged Pensioners'
    mfield='pens'
case msearch='DWCT'
    mfield='dwct'
case msearch='DWCS'
    mfield='dwcs'
case msearch='Turnover'
    mfield='turn'

```

```

endcase

IF not WVISIBLE("lm_plot")
    ACTIVATE WINDOW lm_plot
endif
clear

@0.3,10 to 26.5,10 pen 2
@26.5,10 to 26.5,110 pen 2
@0,0 say 'Residual'
@27,40 say 'There are '+str(mrec,4)+' records in this sample'
@27,80 say msearch
@13,4 say '0.0'
@13.5,10 to 13.5,110 color RGB(200,200,200,255,255,255)

X=0
IF X>5
    i=0.5
    for i=0.5 to 26 step 1.3
        @i,10 to i,110 color RGB(200,200,200,255,255,255)
    endfor
    for j=15.5 to 110 step 5.5
        @0,j to 26.5,j color 'b'
    endfor
ENDIF

mmr=13.00
mml=100.00

mmax=0
mmax2=0
go top
scan
    mturn=turn
    =forecast()
    if mmax<abs(mturn-mfoct)
        mmax=abs(mturn-mfoct)
    endif
    if mmax2<&mfield
        mmax2=&mfield
    endif
endscan

go top
scan
    mturn=turn
    =forecast()
    mr=mmr-(mturn-mfoct)*mmr/mmax+0.5
    ml=&mfield/mmax2*mml+10
    @mr,ml say '*' style 't' color 'r'
endscan
wait 'Press any key' window

release windows lm_plot

procedure res_per
IF NOT WEXIST("lm_pern")
    DEFINE WINDOW lm_pern ;
        AT 0.000, 0.000 ;
        SIZE 30.923,126.800 ;
        FONT "MS Sans Serif", 8 ;
        title "Residual Percentage "+mmsg ;
        FLOAT ;

```

```

                NOCLOSE ;
                MINIMIZE ;
                SYSTEM
ENDIF
IF not WVISIBLE("lm_pern")
    ACTIVATE WINDOW lm_pern
endif

sele 9
go top
do while .not. eof()
*if employ>0
    mturn=turn
    =forecast()
    mdiff=abs(mturn-mfocst)/mturn*100.00
    sele 8
    appe blan
    repl actual with mturn,focst with mfocst,diff with mdiff
    sele 9
*endif
    skip
enddo

sele 8
m0=reccount()
coun for diff<10 to m1
coun for diff<20 to m2
coun for diff<30 to m3
coun for diff<40 to m4
coun for diff<50 to m5
@6,20 say '% Residual less than                               The number of
depots'+;
    ,
    % of the depots'

@8,30 say '10'
@9,30 say '20'
@10,30 say '30'
@11,30 say '40'
@12,30 say '50'
@8,56 say m1
@9,56 say m2
@10,56 say m3
@11,56 say m4
@12,56 say m5
@8,76 say m1/m0*100
@9,76 say m2/m0*100
@10,76 say m3/m0*100
@11,76 say m4/m0*100
@12,76 say m5/m0*100
@20,30 say 'Note: % Residual = ABS ( Actual - Forecast ) / Actual *
100'
wait 'Press any key' window
release windows lm_pern

function forecast
*mfoct=exp(-
23.5)*size^0.661*comp^0.659*carl^0.956*incm^1.57/dwcs^0.026
*mfoct=exp(-
21.459)*size^0.66552*comp^0.5929*carl^1.1051*incm^1.3037/dwcs^0.02491
*mfoct=exp(-7.81)*size^0.591*comp^0.76*carl^0.502*actw^1.68/pens^1.51
*mfoct=exp(-
7.871)*size^0.63815*comp^0.6890*carl^0.7031*actw^1.4571/pens^1.5866/dw
cs^0.01624
*mfoct=exp(-1.726)*size^0.62823*comp^0.6708*carl^0.5824/pens^2.0771

```

```

*mfoct=exp(-8.2261)*size^0.641*comp^0.69*carl^0.71*actw^1.52/pens^1.61
*mfoct=exp(-
10.886)*size^0.62353*comp^0.636*carl^0.7986*incm^0.7104/pens^1.4046
*mfoct=exp(-
22.28)*(log(size))^6.799*comp^0.645*carl^0.9477*incm^0.8578/pens^1.308
/dwcs^0.02258
*mfoct=exp(-
30.785)*(log(size))^6.8467*comp^0.6169*carl^1.1123*incm^1.3232/dwcs^0.
02658
*mfoct=13.45+0.00021013*size+2.0009*comp+0.00000873*popu+0.159*carl-
1.8038*pens-0.00005417*dwcs
*mfoct=-
0.048+0.1213*size/10000+0.13912*comp+0.9*incm/10^7+0.07558*actw+0.0175
7*carl-0.07341*pens
*mfoct=-6.6+0.000317*size-1.46*rank+2.11*comp+1.54*actw-1.90*pens
*mfoct=exp(-
4.354)*size^0.28656*comp^0.24857*actw^0.6293*carl^0.32151/pens^0.4413/
dwcs^0.007712
*mfoct=exp(mfoct)
*mfoct=exp(-
20.721)*size^0.70391*comp^0.4882*carl^0.9768*incm^1.2365/dwcs^0.01126

**** 30/01/95
*mfoct=exp(6.53)*size^0.337*rank^0.0934*comp^0.252*employ^0.581*actw^1
.07/incm^1.43
*mfoct=22.3+0.117*size/1000+0.366*rank+0.957*comp+0.226*employ-
0.955*actw-0.664*pens+0.0123*dwcs/1000
*mfoct=18.5+0.126*size/1000+0.165*rank+1.46*comp+0.225*employ-
0.907*actw-0.524*pens
*mfoct=exp(6.80)*size^0.361*rank^0.141*employ^0.634/incm^1.13
*mfoct=exp(6.18)*size^0.344*rank^0.115*comp^0.173*employ^0.603/incm^1.
06
if mdodo=''
    do lm_turn with ;
    mfoct,size,rank,comp,employ,popu,incm,actw,carl,pens,dwcs,dwct,m
weight
else
    &mdodo
endif

```

```

*          *****
*          *
*          * 23/02/95                LM_AHP.PRG                14:48:38
*          *
*          *****
*          *
*          * Author's Name
*          *
*          * Copyright (c) 1994 Company Name
*          * Address
*          * City,      Zip
*          *
*          * Description:
*          * AHP Analysis
*          *
*          *****

```

on key label fl help p Depot Information

```

*          *****
*          *
*          *                               Windows Window definitions
*          *
*          *****
*

```

```

IF NOT WEXIST("lm_ahp")
    DEFINE WINDOW lm_ahp ;
        AT 0.000, 0.000 ;
        SIZE 30.923,140 ;
        FONT "MS Sans Serif", 8 ;
        title "Global Criteria Structure Tree" ;
        FLOAT ;
        NOCLOSE ;
        MINIMIZE ;
        SYSTEM
ENDIF

IF NOT WEXIST("zoom")
    DEFINE WINDOW zoom ;
        AT 0.000, 0.000 ;
        SIZE 30.923,126 ;
        FONT "MS Sans Serif", 8 ;
        title "Zoom: Local Relationship between the Parent and
Children" ;
        NOCLOSE float minimize ;
        SYSTEM
ENDIF

IF WVISIBLE("lm_ahp")
    ACTIVATE WINDOW lm_ahp SAME
ELSE
    ACTIVATE WINDOW lm_ahp NOSHOW
ENDIF

close database
sele 1
clear
mfile='ahp      '
tcr=0.1
do while .t.
    mcheck1=3

```

```

    @4,26 say 'Please select the tolerance rate for the consistency
check' ;
        style 'b'
    @6,26 say 'The rate should be less than 0.2' style 'b'
    @6,66 say 'TCR= ' style 'b'
    @6,76 get tcr
    @ 10,40 GET mcheck1 PICTURE "@*HT \<New;\<Open;\!?\<Quit" ;
        SIZE 1.769,8,2 FONT "MS Sans Serif", 8 STYLE "B"
    @20,30 say "AHPforWN can only handle the hierarchy with:"
    @21,30 say "Levels: not more than 4"
    @22,30 say "Nodes on each level: not more than 16"
    @23,30 say "Children nodes under each parent node: not more than
9"
        read cycle
        do case
        case mcheck1=1
        *      Check the file name to see whether it is the same as
existing one
            @14,30 say 'Please input the file name' style 'b'
            @14,64 get mfile
            read
            @14,0
            if file(mfile+'.dbf')
                ??chr(7)
                @20,40 say 'The file already exist' style 'B'
                loop
            else
        *      Copy the structure from the source file to the named
file
            use lm_ahp
            copy stru to &mfile
            use &mfile
            endif

        case mcheck1=2
        *      Let the user to select an existing file
            use ?
        *      Check its structure to see whether it is an AHP file
            if .not. (field(1)='PARENT' and field(2)='NAME' and ;
                field(3)='BROTHER')
                ??chr(7)
                @20,40 say 'The selected file is wrong' style 'b'
                loop
            endif

        case mcheck1=3
            release window lm_ahp, zoom
            return
        endcase
        exit
    enddo

set filter to not dele()
sp=space(6)
mname="Goal"
dimension ri(10),w(20)
*      Put the standard figure of RI into the array
ri(1)=0.0
ri(2)=0.0
ri(3)=0.58
ri(4)=0.90
ri(5)=1.12
ri(6)=1.24

```

```

ri(7)=1.32
ri(8)=1.41
ri(9)=1.45
ri(10)=1.49

if eof()
*   Initiate the database
    clear
    @1,40 say 'Please input the objective name'
    do while .t.
        @1,114 say 'Name'
        @3,114 get mname size 1,8
        mexp=space(60)
        @28,2 say 'Explanation: '
        @28,16 get mexp size 1,60
        mcheck2=2
        @ 5,114 GET mcheck2 PICTURE "@*VT \!\?\<OK" ;
            SIZE 1.769,8,0.5 FONT "MS Sans Serif", 8 STYLE "B"
        read cycle
        if mcheck2=1
            exit
        endif
    enddo
    mname=alltrim(mname)
*   Put in the level number
    append blank
    replace figure with 1
*   Add in the top level, i.e., the objective
    append blank
    replace parent with '1', name with mname, figure with 1:0,
explain with mexp
endif

*   Get the height and width of the current window
rwin=wrows()-4
lwin=wcols()-8

*   Display the judgement tree
clear
do while .t.

    @ 1,110 GET mcheck PICTURE "@*VT \!\?\<Quit" ;
        SIZE 1.769,8,0.5 DEFAULT 3 FONT "MS Sans Serif", 8 STYLE
"B"

    r=0.5                                &&    the row place
for each level
    go top
    mlevel=figure
*   The maximum level number is 4
    if mlevel>4
        ??chr(7)
        wait window 'Too many levels'
        exit
    endif
    nlevel=mlevel
    rr=rwin/(mlevel-1)                    &&    The space
between each level
    skip

    l11=0                                &&    The most left place of
parent level

```

```

        l12=0
parent level
        for i=1 to mlevel
            j=str(i,1)
            *      mj: the number of nodes at current level
            count for parent=j to mj
            *      l10: The sapce each joint(push button) occupies
            if mj<13
                l10=lwin/mj
            else
                l10=lwin*2/(mj+1)
            endif
            if l10>=12
                l0=l10/2-6
            else
                l0=0
            endif
            l2l=l0+4
current level
            locate for parent=j
            mr=recno()
            k=0
            *      rk: The sepcial flag for mj>12. In this situation, there
            must
            *      be two tiers for the level. rk=0 for the upper tier,
            *      rk=1 for the lower tier.
            rk=0
            do while parent=j
                k=k+1
                mparent=name
                mname=name
                do case
                case mj<13
                    r0=r
                    lr=l0
                case mj>12 and rk=0
                    r0=r-1.5
                    lr=l0
                    rk=1
                case mj>12 and rk=1
                    r0=r+1.5
                    lr=l0+l10/2
                    rk=0
                endcase
                @ r0,lr GET mname PICTURE "@*H &mname" ;
                SIZE 1.769,8 FONT "MS Sans Serif", 8 STYLE "B"
            valid zoom()
                @r0+2,lr+1 say str(figure,6,3) style 'B'
                if i>1
                    @r-rr/2+2,lr+4 to r0,lr+4  && Draw the
            lines above ;

                the criteria
                endif
                if i<mlevel
                    @r0+3,lr+4 to r+rr/2+1,lr+4  && Draw the lines
            under ;

                the criteria
                endif
                if rk=0
                    l0=l0+l10
                endif

```



```

                                skip
                                enddo
                                l22=l1r+4                                && The most right place
of parent level
                                if i>1
                                    l21=min(l11,l21)
                                    l22=max(l12,l22)
                                    @r-rr/2+1,l21 to r-rr/2+2,l22 pattern 1 color 'b/b'
;
                                                                && Draw
the horizontal lines
                                endif
                                l11=l21
                                l12=l22
                                r=r+rr
                                endfor

                                READ CYCLE
                                if mcheck=1
                                    exit
                                endif
                                enddo
                                pack

                                release window lm_ahp,zoom,lm_ahps

                                function zoom
                                clear
                                IF WVISIBLE("zoom")
                                    ACTIVATE WINDOW zoom SAME
                                ELSE
                                    ACTIVATE WINDOW zoom NOSHOW
                                ENDIF
                                dimension mfigure(50)
                                zname=mname
                                loca for name=mname
                                nlevel=val(parent)                                && Current level
                                number
                                zcode=str(nlevel+1,1)                                && Child level code

                                do while .t.
                                    count for parent=mname and brother=sp to zm
                                    count for parent=zcode to num_node
                                    if zm>0
                                        z11=110/zm
                                        if zm=1
                                            z1=50
                                        else
                                            z1=(110-z11)/2+2
                                        endif
                                    else
                                        z1=50
                                    endif
                                    clear
                                    locate for name=mname
                                    @0,z1 say mname
                                    @1,z1+3 to 2.5,z1+3                                && Draw the first line under
the object
                                    if zm>0
                                        if zm>1
                                            z1=2
                                        endif
                                        go top

```

```

zi=0
@2.5,5 to 2.5,(zm-1)*z11+5    && Draw the horizontal line
scan
    if parent=mname and brother=sp
        zi=zi+1
        @5,z1 say name
        @6,z1 say figure
        @2.5,z1+3 to 4.5,z1+3    && Draw the lines above
the criteria
        @11,10*zi+1 say name
        @zi+11,1 say name
        z1=z1+z11
    endif
endscan
@11,1 say mname
z1=10*(zm+1)/2-10
@9,z1 say 'The Judgement Matrix' style 'B'
zr=12
z1=10
zi=1
zj=1
locate for parent=mname and brother<>sp
do while parent=mname and brother<>sp
    zi=zi+1
    if zi>zm
        zr=zr+1
        zj=zj+1
        z1=zj*10
        zi=zj+1
    endif
    z1=z1+10
    @zr,z1 say figure
    skip
enddo
endif

mjdg=1
@10,105 to 23.5,124
@10.5,107 say 'Judgement' style 'b'
@12,107 say 'Matrix' style 'b'
@13.5,107 say 'Explanation' style 'b'
@11.5,117 get mjdg picture '@*B sample\organize\bmps\help.bmp' ;
    valid explaint()
@15,107 say '1/2 = 0.500'
@16,107 say '1/3 = 0.333'
@17,107 say '1/4 = 0.250'
@18,107 say '1/5 = 0.200'
@19,107 say '1/6 = 0.167'
@20,107 say '1/7 = 0.143'
@21,107 say '1/8 = 0.125'
@22,107 say '1/9 = 0.111'

@24,105 to 28.5,124
@24.5,107 say 'Criteria' style 'b'
@26.5,107 say 'Explanation' style 'b'
@24.5,117 get mjdg picture '@*B sample\organize\bmps\locate.bmp'

;
    valid explain1()

@24,15 to 28.5,90
msen=0
@24.5,40 say "Sensitivity Analysis" FONT "MS Sans Serif", 10
STYLE "B"

```

```

@26,20 get msen picture "@*HT
\<Dynamic;\<Gradient;\<Performance" ;
    SIZE 1.769,18,0.5 FONT "MS Sans Serif", 8 STYLE "B"

mcheck1=5
*
* The maximum level number is 4. If the current level number is 4,
* then disable the <Add> button.
if nlevel>=4 .or. zm>=9 .or. num_node>=16
    mpict="@*VT \<AddNode;\<EditMatrix;\<DeleNode;\!?\<Quit"
else
    mpict="@*VT \<AddNode;\<EditMatrix;\<DeleNode;\!?\<Quit"
endif
@ 1,107 GET mcheck1 PICTURE mpict ;
    SIZE 1.769,12,0.5 DEFAULT 5 FONT "MS Sans Serif", 8 STYLE
"B"

read cycle

zname=name
if msen>0 .and. mlevel>=3
    do lm_ahps with mname,msen
endif

do case
case mcheck1=1
    count for parent=zcode to mchild
    if mchild>0
        copy to array child field name for parent=zcode
    endif
    @1,105 clear to 30,125
    @10,0 clear to 30,125

    mexp=space(60)
    do while .t.
        @1,110 get zname size 1,8
        @28,2 say 'Explanation: '
        @28,16 get mexp size 1,60
        if mchild>0
            @2,110 get msearch from child picture '@^'
default child(1) ;
            valid child_name()
        endif
        @ 5,110 GET mcheck2 PICTURE "@*VT \<OK;\!?\<Cancel"
;
        SIZE 1.769,8,0.5 DEFAULT 2 FONT "MS Sans
Serif", 8 STYLE "B"
        read cycle
        if mcheck2=2
            exit
        endif
        zname=alltrim(zname)
        if len(zname)>0
            locate for name=zname .and. ;
            ((parent>='1' .and. parent<=str(nlevel,1)+' ')
.or. ;
            parent=mname)
        if eof()
            exit
        endif
        ??chr(7)
        @25,20 say 'This name is already exist, please
change'+;
            ' another one' style 'B'

```

```

endif
enddo

if mcheck2=1
  locate for name=zname and parent=zcode
  if eof()
    loca for parent=zcode
    do while parent=zcode
      skip
    enddo
    inse blank before
    replace name with zname,parent with
zcode,explain with mexp  &&Total Weight
  endif
  loca for parent=mname and brother=sp
  do while parent=mname and brother=sp
    skip
  enddo
  inse blank before
  replace name with zname,parent with mname,explain
with mexp  && Single Weight
  if zm>0
    loca for parent=mname and brother<>sp
    if eof()
      skip -2
      zname1=name
      skip 2
      insert blank
      replace parent with mname,name with
zname1,brother with zname
    else
      zname1=name
      do while parent=mname and brother<>sp
        if name<>zname1
          inse blank before
          replace name with
zname1,parent with mname,;
          brother with zname
          && Elements of Judgement Matrix
          skip
          zname1=name
        endif
        skip
      enddo
      skip -1
      zname2=brother
      inse blank
      replace name with zname1,parent with
mname,;
      brother with zname
      inse blank
      replace name with zname2,parent with
mname,;
      brother with zname
    endif
  else
    go 1
    if nlevel>=figure
      replace figure with nlevel+1
    endif
  endif
endif
endif
case mcheck1=2

```

```

locate for parent=mname and brother<>sp

*
@zr,zl clear to 24,100
@1,100 clear to 10,125
@24,0 clear to 30,104

mf=0
do while parent=mname and brother<>sp
    mf=mf+1
    mfigure(mf)=figure
    skip
enddo
nn=mf
do while .t.
    zr=12
    zl=10
    zi=1
    zj=1
    for i=1 to nn
        zi=zi+1
        if zi>zm
            zr=zr+1
            zj=zj+1
            zl=zj*10
            zi=zj+1
        endif
        zl=zl+10
        @zr,zl get mfigure(i) size 1,8
    endfor

    @11.5,117 get mjdg picture '@*B
sample\organize\bmps\help.bmp' ;
    valid explaint()
    @24.5,117 get mjdg picture '@*B
sample\organize\bmps\locate.bmp' ;
    valid explain1()
    mcheck2=3
    @ 5,110 GET mcheck2 PICTURE "@*VT \<OK;\!\\?\<Cancel"

;
    SIZE 1.769,8,0.5 FONT "MS Sans Serif", 8 STYLE
"B"

read cycle

do case
case mcheck2=2
    exit
case mcheck2=1
    mci=0
    mcr=0
*** Calculate the local priorities
do weighting
if zm>2
    mcr=mci/ri(zm)
else
    mcr=0
endif

if mcr<tcr
    @7.5,0
    locate for parent=mname and brother<>sp
    mf=0
    do while parent=mname and brother<>sp
        mf=mf+1

```

```

        replace figure with mfigure(mf)
        skip
    enddo
    locate for parent=mname and brother=sp
    mf=0
    do while parent=mname and brother=sp
        mf=mf+1
        replace figure with w(mf)
        skip
    enddo
    gll=str(nlevel,1)+' '
    gl11=str(nlevel+1,1)+' '
    locate for name=mname and parent=gll
    replace ci with mci,num with zm

***
    Check the global consistency
    locate for parent=gll
    mcr=0
    mci=0
    do while parent=gll
        if num<1
            mcr=0
            exit
        endif
        mcr=mcr+figure*ci
        mci=mci+figure*ri(num)
        skip
    enddo
    mcr=mcr/mci
    if mcr<tcr
        @7.5,0
        Calculate the global priorities
        do global_w
            locate for parent=gl11
            j=0
            do while parent=gl11
                j=j+1
                replace figure with w(j)
                skip
            enddo
            exit
        else
            ??chr(7)
            @7.5,0
            @7.5,0 say 'Global

CR='+str(mcr,8,3)+';
                                '>'+str(tcr,4,1)+' , which
does not meet '+';
                                'the consistency demand.
Please check and '+';
                                'adjust your judgements.'
        endif
    else
        ??chr(7)
        @7.5,0
        @7.5,0 say 'Local
CR='+str(mcr,8,3)+'>'+str(tcr,4,1)+';
                                ' , does not meet the consistency
demand. '+';
                                'Please check and adjust your
judgements.'
    endif
endif

```

```

                endcase
            enddo

            case mcheck1=3 and zm>0
do while .t.
    @1,0 clear to 30,124
    @0,105 clear to 30,125
        z1=2
        go top
        zmm="@*HT "
        d_name=name
        scan
            if parent=mname and brother=sp
                if len(zmm)<6
                    zmm=zmm+name
                else
                    zmm=zmm+";"+name
                endif
            endif
        endscan
    @1,110 clear to 10,125
    @5,0
    if zm>1
        lr=2
    else
        lr=50
    endif
    @ 4.55,lr GET d_name PICTURE zmm ;
        SIZE 1.5,8,z11-8 ;
        valid f_dele()
    mcheck3=0
    @ 3,110 GET mcheck3 PICTURE "@*VT \!\?<Quit" ;
        SIZE 1.769,8,0.5 FONT "MS Sans Serif", 8 STYLE "B"
    read cycle
    if mcheck3=1
        exit
    endif
enddo

    case mcheck1=4
        exit
    endcase
enddo
clear read

function f_dele
* Confirm and delete the criterion

@4,col()-2 to 7.5,col()+9
@1,110 clear to 10,125
    @ 5,110 GET mcheck2 PICTURE "@*VT \<Dele;\!\?<Cancel" ;
        SIZE 1.769,8,0.5 DEFAULT 2 FONT "MS Sans Serif", 8 STYLE
"B"
read cycle
if mcheck2=1
    dele for parent=d_name or name=d_name or brother=d_name
*   dele for parent=mname and (name=d_name or brother=d_name)
*   locate for name=d_name and len(trim(parent))>1
*   if eof()
*       dele for name=d_name
*   endif
    locate for parent>=zcode
    if eof()
        go 1
    endif
endif

```

```

        replace figure with nlevel
    endif
endif
clear read

function explaint
* Explain the Judgement Matrix

IF NOT WEXIST("expl")
    DEFINE WINDOW expl ;
        AT 0.000, 20.000 ;
        SIZE 25,68 ;
        FONT "Courier New", 8 ;
        title "Judgement Matrix Explanation" ;
        in window zoom ;
        NOCLOSE ;
        SYSTEM
ENDIF

IF WVISIBLE("expl")
    ACTIVATE WINDOW expl SAME
ELSE
    ACTIVATE WINDOW expl NOSHOW
ENDIF

@0,14 say 'Scale of Ralative Importance' style 'b'
@2,0 say 'Judgement      Definition      Explanation'
@3,0 to 3,9
@3,11 to 3,30
@3,33 to 3,67
@4,1 say '1          Equal importance.      Two activities contribute
equally'
@5,1 say '          Moderate importance    to the objective.'
@6,1 say '3          of one over another.  Experience and judgement
slightly'
@7,1 say '          Essential or strong   favor one activity over
another.'
@8,1 say '5          importance.           Experience and judgement
strongly'
@9,1 say '          Demonstrated          favor one activity over
another.'
@10,1 say '7         importance.           An activity is strongly
favored'
@11,1 say '          Extreme importance.  and its dominance is
demonstrated'
@12,1 say '          The evidence favoring one
in practice.'
@13,1 say '9         over another is one of the
activity'
@14,1 say '          possible order of
highest'
@15,1 say '          When compromise is
affirmation'
@16,1 say '2,4,6,8   Intermediate values
needed.'
@17,1 say '          between the two'
@18,1 say '          adjacent judgements.'
@19,1 say 'Decimal   If an activity has one of the above numbers'
@20,1 say 'of above  (e.g. 3) compared with a second activity, then'
@21,1 say 'non-zero  the second activity has the reciprocal calue'
@22,1 say 'numbers   (i.e., 1/3=0.333) when compared to the first.'
@23,60 get mexpl picture '@* \<Quit' ;
        SIZE 1.769,8 DEFAULT 1 FONT "MS Sans Serif", 8 STYLE "B"

```



```

read
clear read
release window expl

function explain1
** Explain the meaning of the criteria

IF NOT WEXIST("expl1")
    DEFINE WINDOW expl1 ;
        AT 0.000, 6.000 ;
        SIZE 25,80 ;
        FONT "Courier New", 8 ;
        title "Criteria Explanation" ;
        in window zoom ;
        NOCLOSE ;
        SYSTEM
ENDIF

IF WVISIBLE("expl1")
    ACTIVATE WINDOW expl1 SAME
ELSE
    ACTIVATE WINDOW expl1 NOSHOW
ENDIF

    dimension mexpn1(20),mexpn2(20)
*mr=recn()
    locate for name=mname
    r=1.5
    @r,2 say name FONT "MS Sans Serif", 8 style 'B'
        mexpn1(1)=explain
        mexpn2(1)=explain
*@r,10 say explain FONT "MS Sans Serif", 8 style 'B'
    r=1.5
    i=1
    scan
        if parent=mname and brother=sp
            r=r+1.5
            @r,2 say name+'  :'
            i=i+1
            mexpn1(i)=explain
            mexpn2(i)=explain
        endif
    endscan

    do while .t.
        r=0
        for j=1 to i
            r=r+1.5
            @r,11 get mexpn1(j) size 1,64
        endfor

        mexpl=0
        @23,60 get mexpl picture '@*H \<OK;\<Cancel' ;
            SIZE 1.769,8 FONT "MS Sans Serif", 8 STYLE "B"
        read cycle
        do case
        case mexpl=1
            for j=1 to i
                if mexpn1(j)<>mexpn2(j)
                    repl explain with mexpn1(j) for
explain=mexpn2(j)
                endif
            endfor
        endcase
    enddo

```

```

                exit
            case mexpl=2
                exit
            endcase
        enddo

*go mr
*clear read
release window expl1

procedure weighting
* Local priorities calculation

dimension c(zm,zm),u(zm)
k=0
for i=1 to zm-1
    for j=i+1 to zm
        k=k+1
        c(i,j)=mfigure(k)
        c(j,i)=1/c(i,j)
    endfor
    c(i,i)=1
endfor
c(zm,zm)=1

t4=0
for i=1 to zm
    s=1
    for j=1 to zm
        s=s*c(i,j)
    endfor
    s=s^(1/zm)
    u(i)=s
    t4=t4+s
endfor
for i=1 to zm
    u(i)=u(i)/t4
endfor
k=0
do while k<=100
    k=k+1
    t4=0
    for i=1 to zm
        s=0
        for j=1 to zm
            s=s+c(i,j)*u(j)
        endfor
        w(i)=s
        t4=t4+s
    endfor
    d=0
    for i=1 to zm
        w(i)=w(i)/t4
        d=d+abs(w(i)-u(i))
    endfor
    if d<1e-5
        exit
    endif
    for i=1 to zm
        u(i)=w(i)
    endfor
enddo

```

```

mci=(t4-zm)/(zm-1)

procedure global_w
* Global priorities calculation

dimension ga(20),gb(20,20),gnm(20)

for i=1 to 20
    ga(i)=0
    w(i)=0
    gnm(i)=''
    for j=1 to 20
        gb(i,j)=0
    endfor
endfor

gll=str(nlevel,1)+' '
glll=str(nlevel+1,1)+' '
locate for parent=glll
j=0
do while parent=glll
    j=j+1
    gnm(j)=name
    skip
enddo
gn=j

locate for parent=gll
j=0
do while parent=gll
    j=j+1
    ga(j)=figure
    gname=name
    mr=recn()
    locate for parent=gname and brother=sp
    do while parent=gname and brother=sp
        for i=1 to gn
            if gnm(i)=trim(name)
                gb(i,j)=figure
                exit
            endif
        endfor
        skip
    enddo
    go mr
    skip
enddo

for ii=1 to gn
    w(ii)=0
    for jj=1 to j
        w(ii)=w(ii)+gb(ii,jj)*ga(jj)
    endfor
endfor

function child_name
*mr=recn()
locate for name=msearch
@1,110 say msearch
@28,16 say explain
mexp=explain
zname=msearch
*go mr

```

Procedure sensitivity

```

* AHP sensitivity analysis
parameter mname,msen

```

```

dimension ga(20),gb(20,20),gnm(20),w(20),wa(20)
sp=space(6)
*mname='Cost'
*use dyer
go top
mll=figure-1

```

```

IF WVISIBLE("lm_ahps")
    ACTIVATE WINDOW lm_ahps SAME
ELSE
    ACTIVATE WINDOW lm_ahps NOSHOW
ENDIF

```

```

for i=1 to 20
    store 0 to wa(i),ga(i),w(i)
    gnm(i)=''
    for j=1 to 20
        gb(i,j)=0
    endfor
endfor

```

```

locate for name=mname
nlevel=val(substr(parent,1))
gll=str(nlevel,1)+' '

```

```

clear
@1,20 say "Selected Criterion: "
@1,42 say mname style "B"
@3,20 say "Change the weight to"
locate for parent=gll
ii=0
i=0
r=4

```

```

do while parent=gll
    i=i+1
    wa(i)=figure
    * gnm(i)=name
    r=r+1.5
    @r,4 say name
    if name=mname
        iselect=i
    endif
    skip
enddo
inum=i

```

```

mexpl=0
wsii=wa(iselect)
do while .t.
    @3,42 get wsii spinner 0.02,0.0,1.0 size 1,6
    @23,40 get mexpl picture '@*H \!\<OK;\?\<Quit' ;
        SIZE 1.769,8 DEFAULT 1 FONT "MS Sans Serif", 8 STYLE "B"

```

```

read
do case
case mexpl=1
do sensitivity

```

```

case mexpl=2
exit
endcase
enddo

procedure sensitivity

*      Change the weights on the selected level by keeping
*      the same previous proportion.

asum=0
if iselect=1
    wsl=wa(2)
else
    wsl=wa(1)
endif
for j=1 to inum
    if j<>iselect
        asum=asum+wa(j)/wsl
    endif
endfor
if iselect=1
    ga(1)=wsii
    ga(2)=(1-wsii)/asum
    wsl1=ga(2)
    jj=3
else
    ga(1)=(1-wsii)/asum
    wsl1=ga(1)
    jj=2
endif
for j=jj to inum
    if j=iselect
        ga(j)=wsii
    else
        ga(j)=wsl1*wa(j)/wsl
    endif
endfor
r=4
for i=1 to inum
    r=r+1.5
    l=ga(i)*20+20
*      @r,4 say gnm(i)
    @r,14 say round(ga(i),3) pict "9.999"
    @r,20 to r+1,40 clear
    @r,20 to r+1,1 pattern 1 color b/b
endfor

*      Recalculate the weights below the selected level.

for mlevel=nlevel to mll
    gl1=str(mlevel,1)+' '
    gl11=str(mlevel+1,1)+' '
    locate for parent=gl11
    j=0
    do while parent=gl11
        j=j+1
        gnm(j)=name
        skip
    enddo
    gn=j

    locate for parent=gl1

```

```

j=0
do while parent=gll
    j=j+1
    *   ga(j)=figure
        gname=name
        mr=recn()
        locate for parent=gname and brother=sp
        do while parent=gname and brother=sp
            for i=1 to gn
                if gnm(i)=trim(name)
                    gb(i,j)=figure
                    exit
                endif
            endfor
            skip
        enddo
        go mr
        skip
    enddo

    for ii=1 to gn
        w(ii)=0
        for jj=1 to j
            w(ii)=w(ii)+gb(ii,jj)*ga(jj)
        endfor
    endfor

    for i=1 to gn
        ga(ii)=w(ii)
    endfor

    if mlevel=mll
        r=4
        for i=1 to gn
            ga(ii)=w(ii)
            r=r+1.5
            l=w(i)*20+60
            @r,44 say gnm(i)
            @r,54 say round(w(i),3) pict "9.999"
            @r,60 to r+1,80 clear
            @r,60 to r+1,1 pattern 1 color b/b
        endfor
    endif
endfor

```

```

*          *****
*          *
*          * 30/08/94          LM_EXPL.PRG          14:48:38
*          *
*          *****
*          *
*          * Author's Name
*          *
*          * Copyright (c) 1994 Company Name
*          * Address
*          * City,      Zip
*          *
*          * Description:
*          * This program automatically export the demographic
information
*          * to an external ASCII file.
*          *
*          *****

sp=space(30)
close database

dimension c_char(4)
m.choice=1
mdet=1
x=0

sele 11
use lm_cust index lm_custp
sele 9
use lm_compl
sele 5
use lm_expl
sele 4
use lm_cacil
sele distinct groupn from lm_dept into array c_grp
sele 13
use lm_mult index lm_multp
sele 1
use lm_dept index lm_deftp
sele distinct county from lm_dept into array c_county
c_char(1)='Depot Turnover'
c_char(2)='Depot Size'
c_char(3)='Depot Ranking'
c_char(4)='Price Competitiveness'

*set topic to 'p Depot Information'
on key label fl help p export1

*          *****
*          *
*          *          Windows Window definitions
*          *
*          *****
*

IF NOT WEXIST("lm_expl")
    DEFINE WINDOW lm_expl ;
        AT 0.000, 0.000 ;
        SIZE 30.923,126.800 ;
        FONT "MS Sans Serif", 8 ;
        title "Demographic Information Export" ;
        FLOAT ;

```

```

        NOCLOSE ;
        MINIMIZE ;
        SYSTEM
ENDIF

*          *****
*          *
*          *          LM_EXPL/Windows Screen Layout
*          *
*          *****
*

#REGION 1
IF WVISIBLE("lm_expl")
    ACTIVATE WINDOW lm_expl SAME
ELSE
    ACTIVATE WINDOW lm_expl NOSHOW
ENDIF

msearch1=1
mfile='landmark.txt'
mcpt=1
do while .t.

@ 5.692,76.400 GET menquiry ;
    PICTURE "@^T \<Group Name;Co\<unty;C\<haracteristics" ;
    SIZE 1.538,18.333 ;
    DEFAULT "Group Name" ;
    FONT "MS Sans Serif", 8 ;
    STYLE "B"

@1,0 clear to 26,70
do case
case menquiry="Group Name"
    @5.692,16.400 get msearch from c_grp size 16,32 ;
        FONT "MS Sans Serif", 8 ;
        STYLE "B" defa c_grp(1)
* when refresh()

case menquiry="County"
    @5.692,16.400 get msearch from c_county size 16,32 ;
        FONT "MS Sans Serif", 8 ;
        STYLE "B" defa c_county(1)

case menquiry='Characteristics'
    @ 5.692,26.400 GET msearch1 ;
        PICTURE "@*RVT Depot Turnover;Depot Size;Depot
Ranking;Price Competitiveness" ;
        SIZE 1.308,25.000,0.308 ;
        FONT "MS Sans Serif", 8 ;
        STYLE "BT"
    @14,26.4 say 'Please choose the search range' ;
        FONT "MS Sans Serif", 8 STYLE "BT"

    @16,26.4 say 'Upper level: ' ;
        FONT "MS Sans Serif", 8 STYLE "BT"
    @18,26.4 say 'Lower level: ' ;
        FONT "MS Sans Serif", 8 STYLE "BT"
do case
case msearch1=1
    mmax=20.0
    mmin=20.0

```



```

@ 16,44 GET mmax ;
SPINNER 2.0, 0, 100 ;
PICTURE "@K" ;
SIZE 0.846, 6.400 ;
DEFAULT 20.0 ;
FONT "MS Sans Serif", 8
@ 18,44 GET mmin ;
SPINNER 2.0, 0, 100 ;
PICTURE "@K" ;
SIZE 0.846, 6.400 ;
DEFAULT 20.0 ;
FONT "MS Sans Serif", 8
case msearch1=2
  mmax=80000
  mmin=80000
  @ 16,44 GET mmax ;
  SPINNER 200, 0, 500000 ;
  PICTURE "@K" ;
  SIZE 0.846, 8.400 ;
  FONT "MS Sans Serif", 8
  @ 18,44 GET mmin ;
  SPINNER 200, 0, 500000 ;
  PICTURE "@K" ;
  SIZE 0.846, 8.400 ;
  DEFAULT 80000 ;
  FONT "MS Sans Serif", 8
case msearch1=3
  mmax=6
  mmin=6
  @ 16,44 GET mmax ;
  SPINNER 1, 0, 9 ;
  PICTURE "@K" ;
  SIZE 0.846, 4.400 ;
  FONT "MS Sans Serif", 8
  @ 18,44 GET mmin ;
  SPINNER 1, 0, 9 ;
  PICTURE "@K" ;
  SIZE 0.846, 4.400 ;
  FONT "MS Sans Serif", 8
case msearch1=4
  mmax=6
  mmin=6
  @ 16,44 GET mmax ;
  SPINNER 1, 0, 9 ;
  PICTURE "@K" ;
  SIZE 0.846, 4.400 ;
  FONT "MS Sans Serif", 8
  @ 18,44 GET mmin ;
  SPINNER 1, 0, 9 ;
  PICTURE "@K" ;
  SIZE 0.846, 4.400 ;
  FONT "MS Sans Serif", 8
endcase

endcase

@8,76.4 say 'Competitors:' style 'b'
@9,76.4 GET mcpt ;
  PICTURE "@*RVT C & C plus Multiples;Cash & Carry only" ;
  SIZE 1.308,25.000,0.308 ;
  FONT "MS Sans Serif", 8 ;
  STYLE "BT"

mexp=0.50

```

```

@12.5,76.4 say 'Distance Weighted' ;
        FONT "MS Sans Serif", 8 STYLE "BT"
@14.5,76.4 say 'Power: ' ;
        FONT "MS Sans Serif", 8 STYLE "BT"
@14.5,90 GET mexp ;
        SPINNER 0.05, 0.00, 9.00 ;
        PICTURE "@K" ;
        SIZE 0.846, 5.400 ;
        FONT "MS Sans Serif", 8
@16.5,76.4 say 'Export Filename:' ;
        FONT "MS Sans Serif", 8 STYLE "BT"
@18,76.4 get mfile

mcheck=3
@ 20,76.800 GET mcheck ;
        PICTURE "@*HT \\<OK;\\?\\<Quit" ;
        SIZE 1.769,8.667,1.333 ;
        DEFAULT 3 ;
        FONT "MS Sans Serif", 8 ;
        STYLE "B"

READ CYCLE

IF NOT WVISIBLE("lm_exp1")
        ACTIVATE WINDOW lm_exp1
ENDIF

do case
case mcheck=2
        exit
case mcheck>2
        loop
endcase

do case
case menquiry="Group Name"
        mdd=trim(msearch)
        mdd=upper(mdd)
        mcond="groupn=mdd"
        mm='for '+trim(msearch)+' Group'
        do export

case menquiry="County"
        mdd=trim(msearch)
        mdd=upper(mdd)
        mcond="mdd$county"
        mm='in '+trim(msearch)
        do export

case menquiry="Characteristics"
        msel3=0
        sele 1
        do case
        case msearch1=1
                mcond="turnoverxx>=mmin .and. turnoverxx<=mmax"
                m1=str(mmin,5,1)
                m2=str(mmax,5,2)
                mm='with Turnover Between &m1 and &m2'
        case msearch1=2
                mcond="size__sq_f>=mmin .and. size__sq_f<=mmax"
                m1=str(mmin,7)
                m2=str(mmax,7)
                mm='with Size Between &m1 and &m2'

```

```

        case msearch1=3
            mcond='depot_rank>=mmin .and. depot_rank<=mmax'
            m1=str(mmin,2)
            m2=str(mmax,2)
            mm='with Rank Between &m1 and &m2'
        case msearch1=4
            mcond='price_comp>=mmin .and. price_comp<=mmax'
            m1=str(mmin,2)
            m2=str(mmax,2)
            mm='with Pricing Between &m1 and &m2'
        endcase
    do export

endcase
clear
exit

enddo

set filter to
RELEASE WINDOW lm_exp1

*return

procedure export
*mexp=0.5
sele 5
set safe off
zap
set safe on

sele 1
go top
do while .not. eof()
    if &mcond
        mdepot=depot
        mpost=post_code
        npost=substr(post_code,1,6)
        mpd=mpost+mdepot
        mrec=recno()
        mdwcs=1
        mdwct=1

        sele 4
        loca for postcode=npost
        if .not. eof()

            mcust=0
            sele 9
            locate for postcode=npost and dist=0
            if .not. eof()
                do while .t.
                    if dist<999.9
                        mcustp=postcode
                        if dist<0.1
                            mdist=0.1
                        endif
                        mdist=mdist^mexp

                        sele 11
                        seek mcustp
                        if .not. eof()
                            do while postcode=mcustp

```

```

                                mcust=mcust+1
                                skip
                            enddo
                        endif

                        sele 1
                        seek mcustp
                        do while post_code=mcustp
                            mdwct=mdwct+turnoverxx/mdist
                            mdwcs=mdwcs+size__sq_f
                        skip
                        enddo

                        if mcpt=1
                            sele 13
                            seek mcustp
                            do while postcode=mcustp
                                mdwcs=mdwcs+sales_area
                                skip
                            enddo
                        endif

                        sele 9
                    endif
                    skip
                    if dist<0.1
                        exit
                    endif
                enddo
            endif

            sele 1
            go mrec
            sele 5
            appe blan
            repl depot with mdepot,postcode with mpost,turn with
a->turnoverxx,;
                                size with a->size__sq_f,rank with a-
>depot_rank,;
                                comp with a->price_comp,employ with a-
>employee,;
                                popu with d->popu,incm with d->income,;
                                actw with d->actw,carl with d->carl,pens with
d->pens,;
                                dwct with mdwct,dwcs with mdwcs,cust with
mcust
                                endif
                                sele 1
                            endif
                            skip
                        enddo
                        sele 5
                        set safe off
                        copy fields turn,size,rank,comp,employ,popu,incm,actw,carl,pens,dwct,;
                            dwcs,cust to &mfile sdf
                        set safe on
                        use lm_expl1
                        repl msg with mm,weight with mexp

```

```

* *****
*
* 20/06/94 LM_chng1.PRG 14:48:38
*
* *****
*
* Author's Name
*
* Copyright (c) 1994 Company Name
* Address
* City, Zip
*
* Description:
* This program was automatically generated by GENSCRN.
*
* *****

```

```

sp=space(30)
close database
set dele on
sele 1
use lm_dept index lm_deptd,lm_deptp,lm_deptc
sele distinct depot+post_code from lm_dept into array c_depot
sele distinct groupn from lm_dept into array c_grp

```

```

* *****
*
* Windows Window definitions
*
* *****
*

```

```

on key label f1 help p Modify

```

```

IF NOT WEXIST("lm_chng1")
    DEFINE WINDOW lm_chng1 ;
        AT 0.000, 0.000 ;
        SIZE 30.923,126.800 ;
        FONT "MS Sans Serif", 8 ;
        title "Depot Information Database Modifaction" ;
        FLOAT ;
        NOCLOSE ;
        MINIMIZE ;
        SYSTEM
ENDIF

```

```

* *****
*
* LM_chng1/Windows Screen Layout
*
* *****
*

```

```

#REGION 1
IF WVISIBLE("lm_chng1")
    ACTIVATE WINDOW lm_chng1 SAME
ELSE
    ACTIVATE WINDOW lm_chng1 NOSHOW
ENDIF

```

```

mdepot=depot
mpost=post_code

```

```

do while .t.
clear
@ 3.3,78 GET menquiry ;
PICTURE "@^T By \<Depot;By \<Group" ;
SIZE 1.538,18.333 ;
DEFAULT "By Depot" ;
FONT "MS Sans Serif", 8 ;
STYLE "B" ;

if menquiry="By Depot"
    @5.692,16.400 get msearch from c_depot size 16,36 ;
        font 'Fixedsys',9 ;
        defa c_depot(1) when refresh()
    @ 3.692,17.000 GET mdepot ;
        SIZE 1,25 pict "@!" ;
        font 'Fixedsys',9 style 't'
    @ 3.692,57.000 GET mpost ;
        SIZE 1,8 pict "@!" ;
        font 'Fixedsys',9 style 't'
else
    @5.692,16.400 get msearch from c_grp size 16,36 ;
        font 'Fixedsys',9 ;
        defa c_grp(1) when refresh()
endif

@ 3.292,16.400 to 4.992,74.400 double
mcheck=0
@ 19.615,76.800 GET mcheck ;
PICTURE "@*HT \!\<OK;\?\<Quit" ;
SIZE 1.769,8.667,1.333 ;
DEFAULT 1 ;
FONT "MS Sans Serif", 8 ;
STYLE "B"
read cycle

do case
case mcheck=0
    loop
case mcheck=2
    exit
endcase

if menquiry="By Depot"
    mdd=trim(mdepot)
    mpp=trim(mpost)
    if len(mpp)<1
        mpp=' '
    endif
    mcond="mdd$depot .and. mpp$post_code"
else
    mdd=trim(msearch)
    mcond="groupn=mdd"
endif
loca for &mcond
if .not. eof()
clear
on key label f1 help Database Modification

do while .t.
    @ 4.023,16.000 SAY "Depot" ;
        FONT "MS Sans Serif", 8 STYLE "BT"
    @ 5.023,16.000 SAY "Location" ;
        FONT "MS Sans Serif", 8 STYLE "BT"

```

```

@ 5.023,68.800 SAY "County" ;
    FONT "MS Sans Serif", 8 STYLE "BT"
@ 6.023,16.000 SAY "Post_code" ;
    FONT "MS Sans Serif", 8 STYLE "BT"
@ 6.023,68.800 SAY "Group" ;
    FONT "MS Sans Serif", 8 STYLE "BT"
@ 7.023,16 say '-----
- '+';
    ' Characteristics -----
-----' ;
    FONT "MS Sans Serif", 8 STYLE "BT"
@ 8.023,16.000 SAY "Turnover" ;
    FONT "MS Sans Serif", 8 STYLE "BT"
@ 8.023,38.400 SAY "Size" ;
    FONT "MS Sans Serif", 8 STYLE "BT"
@ 8.023,55.400 SAY "Depot_rank" ;
    FONT "MS Sans Serif", 8 STYLE "BT"
@ 8.023,73.400 SAY "Price_comp" ;
    FONT "MS Sans Serif", 8 STYLE "BT"
@ 8.023,92 say 'F.T.E.' ;
    FONT "MS Sans Serif", 8 STYLE "BT"
@ 4.023,30.800 SAY depot ;
    SIZE 1.000,33.800 FONT "MS Sans Serif", 8
@ 5.023,30.800 SAY location ;
    SIZE 1.000,26.800 FONT "MS Sans Serif", 8
@ 5.023,78.800 SAY county ;
    SIZE 1.000,27.000 FONT "MS Sans Serif", 8
@ 6.023,30.800 SAY post_code ;
    SIZE 1.000,16.000 FONT "MS Sans Serif", 8
@ 6.023,78.800 SAY groupn ;
    SIZE 1.000,27.000 FONT "MS Sans Serif", 8
@ 8.023,28.800 SAY turnoverxx ;
    SIZE 1.000,7.400 FONT "MS Sans Serif", 8
@ 8.023,45.400 SAY size__sq_f ;
    SIZE 1.000,8.200 FONT "MS Sans Serif", 8
@ 8.023,68.800 SAY depot_rank ;
    SIZE 1.000,3.000 FONT "MS Sans Serif", 8
@ 8.023,86.800 SAY price_comp ;
    SIZE 1.000,3.000 FONT "MS Sans Serif", 8
@ 8.023,98 say employee ;
    SIZE 1.000,6.200 FONT "MS Sans Serif", 8

mrec=recn()
do while .not. eof()
    skip
    if &mcond
        exit
    endif
enddo
if eof()
    mnext='\\'
    mnextl=mrec
else
    mnext=''
    mnextl=recn()
endif
go mrec
do while .not. bof()
    skip -1
    if &mcond
        exit
    endif
enddo

```

```

if bof()
    mprev='\\'
    mprevl=mrec
else
    mprev=''
    mprevl=recn()
endif
go mrec

@ 20.000,20.000 GET m.choice ;
    PICTURE "@*HT \<Edit;\<Insert;\<Delete;"+;
    mnext+"\\!\<Next;"+mprev+"\\<Previous;\<Quit" ;
    SIZE 1.769,10.333,0.308 ;
    DEFAULT 1 ;
    FONT "MS Sans Serif", 8 ;
    STYLE "B"

read cycle

do case
case m.choice=1
    scatter memvar
    do edit_pro
case m.choice=2
    scatter memvar blank
    do edit_pro
    go mrec
case m.choice=3
    ??chr(7)
    @14,0 clear to 26,100
    @16,32 say "The current depot information will be
deleted !" ;
        FONT "MS Sans Serif", 8 ;
        STYLE "B"
    @ 20.000,44.000 GET m.choicel ;
    PICTURE "@*HT \<OK;\\!\<Cancel" ;
    SIZE 1.769,10.333,0.308 ;
    DEFAULT 2 ;
    FONT "MS Sans Serif", 8 ;
    STYLE "B"

read cycle

@14,0 clear to 26,100

if m.choicel=1
    dele
sele distinct depot+post_code from lm_dept into array c_depot
sele distinct groupn from lm_dept into array c_grp
    do case
    case mrec<>mnex1
        go mnex1
    case mrec<>mprev1
        go mprev1
    otherwise
        exit
    endcase
endif
case m.choice=4
    go mnex1
case m.choice=5
    go mprev1
case m.choice=6

```



```

                                exit
                        endcase

                enddo
                endif
                msearch=""

        enddo
        set dele off
        pack
        release window lm_chng1

function refresh
mdepot=substr(msearch,1,25)
mpost=substr(msearch,26,8)
@3.692,17.400 say space(86)
@ 3.692,17.000 say mdepot ;
        SIZE 1,30 pict "@" ;
        font 'Fixedsys',9
@ 3.692,57.000 say mpost ;
        SIZE 1,10 pict "@" ;
        font 'Fixedsys',9

procedure edit_pro
        @16,0 clear to 26,100
        do while .t.
                @ 4.023,16.000 SAY "Depot" ;
                        FONT "MS Sans Serif", 8 STYLE "BT"
                @ 5.023,16.000 SAY "Location" ;
                        FONT "MS Sans Serif", 8 STYLE "BT"
                @ 5.023,68.800 SAY "County" ;
                        FONT "MS Sans Serif", 8 STYLE "BT"
                @ 6.023,16.000 SAY "Post_code" ;
                        FONT "MS Sans Serif", 8 STYLE "BT"
                @ 6.023,68.800 SAY "Group" ;
                        FONT "MS Sans Serif", 8 STYLE "BT"
                @ 7.023,16 say '-----'
        -'+;
                ' Characteristics -----
        -----' ;
                FONT "MS Sans Serif", 8 STYLE "BT"
                @ 8.023,16.000 SAY "Turnover" ;
                        FONT "MS Sans Serif", 8 STYLE "BT"
                @ 8.023,38.400 SAY "Size" ;
                        FONT "MS Sans Serif", 8 STYLE "BT"
                @ 8.023,55.400 SAY "Depot_rank" ;
                        FONT "MS Sans Serif", 8 STYLE "BT"
                @ 8.023,73.400 SAY "Price_comp" ;
                        FONT "MS Sans Serif", 8 STYLE "BT"
                @ 8.023,92 say 'F.T.E.' ;
                        FONT "MS Sans Serif", 8 STYLE "BT"
                @ 4.023,30.800 get m.depot ;
                        SIZE 1.000,33.800 FONT "MS Sans Serif", 8 pict "@"
                @ 5.023,30.800 get m.location ;
                        SIZE 1.000,26.800 FONT "MS Sans Serif", 8
                @ 5.023,78.800 get m.county ;
                        SIZE 1.000,27.000 FONT "MS Sans Serif", 8
                @ 6.023,30.800 get m.post_code ;
                        SIZE 1.000,16.000 FONT "MS Sans Serif", 8 pict
        "!!!!!!!!!"
                @ 6.023,78.800 get m.groupn ;
                        SIZE 1.000,27.000 FONT "MS Sans Serif", 8 pict "@"
                @ 8.023,28.800 get m.turnoverxx ;

```

```

        SIZE 1.000,7.400 FONT "MS Sans Serif", 8 pict
"999.9"
        @ 8.023,45.400 get m.size__sq_f ;
        SIZE 1.000,8.200 FONT "MS Sans Serif", 8 pict
"99999999"
        @ 8.023,68.800 get m.depot_rank ;
        SIZE 1.000,3.000 FONT "MS Sans Serif", 8 pict "9"
        @ 8.023,86.800 get m.price_comp ;
        SIZE 1.000,3.000 FONT "MS Sans Serif", 8 pict "9"
        @ 8.023,98 get m.employee ;
        SIZE 1.000,6.200 FONT "MS Sans Serif", 8 pict
"999.9"

        @ 20.000,48.000 GET m.choicel ;
        PICTURE "@*HT \<OK;\<Cancel" ;
        SIZE 1.769,10.333,0.308 ;
        DEFAULT 2 ;
        FONT "MS Sans Serif", 8 ;
        STYLE "B"
read cycle

if m.choicel=1
    if len(m.post_code)=8
        mp1=substr(m.post_code,1,1)
        mp2=substr(m.post_code,5,1)
        mp3=substr(m.post_code,6,1)
        if mp1<="Z" .and. mp1>="A" .and. mp2=" " .and.
;
            mp3<="9" .and. mp3>="0"
            if m.choice=2
                append blank
            endif
            if m.groupn="LANDMARK"
                m.member="Y"
            else
                m.member="N"
            endif
            gather memvar
sele distinct depot+post_code from lm_dept into array c_depot
sele distinct groupn from lm_dept into array c_grp
        exit
    endif
endif
??chr(7)
@16,40 say "The postcode format is wrong !" ;
FONT "MS Sans Serif", 8 ;
STYLE "B"
loop
endif
exit
enddo
@16,0 clear to 26,100

```

```

*          *****
*          *
*          * 29/06/94          LM_dmgh.PRG          14:48:38
*          *
*          *****
*          *
*          * Author's Name
*          *
*          * Copyright (c) 1994 Company Name
*          * Address
*          * City,          Zip
*          *
*          * Description:
*          * This program was automatically generated by GENSCRN.
*          *
*          *****

```

```

close database
sele 13
use lm_mult index lm_multp
sele 11
use lm_cust index lm_custp
sele 12
use county_d
sele 8
use lm_contd
sele distinct county from lm_contd into array c_county
sele 9
use lm_compl
sele 4
use lm_cacil
sele distinct postcode from lm_cacil into array c_post
sele 1
use lm_dept index lm_deftp

```

```

*          *****
*          *
*          *          Windows Window definitions
*          *
*          *****
*

```

on key label f1 help p Demographic Information

```

IF NOT WEXIST("lm_dmgh")
    DEFINE WINDOW lm_dmgh ;
        AT 0.000, 0.000 ;
        SIZE 30.3,126.800 ;
        FONT "MS Sans Serif", 8 ;
        title "Demographic Information Enquiry" ;
        FLOAT ;
        NOCLOSE ;
        MINIMIZE ;
        SYSTEM

```

ENDIF

```

IF NOT WEXIST("lm_brow")
    DEFINE WINDOW lm_brow ;
        AT 3.50, 42.000 ;
        SIZE 22.5,30 ;
        FONT "MS Sans Serif", 8 ;
        in window lm_dmgh ;
        title "Composition" ;
        none

```

ENDIF

```
*          *****
*          *
*          *          LM_DTQ/Windows Screen Layout
*          *
*          *****
*
```

```
#REGION 1
IF WVISIBLE("lm_dmgh")
    ACTIVATE WINDOW lm_dmgh SAME
ELSE
    ACTIVATE WINDOW lm_dmgh NOSHOW
ENDIF
```

```
msearch1=1
do while .t.
```

```
    @ 3.692,76.400 GET menquiry ;
        PICTURE "@^T \<Catchment;Co\<unty" ;
        SIZE 1.538,18.333 ;
        DEFAULT "Catchment" ;
        FONT "MS Sans Serif", 8 ;
        STYLE "B"
```

```
do case
case enquiry="Catchment"
```

```
    @3.692,16.400 get msearch from c_post size 24,20 ;
        FONT "MS Sans Serif", 8 ;
        STYLE "B" defa c_post(1) when refresh()
```

```
case enquiry="County"
```

```
msearch1=c_county(1)
    @3.692,16.400 get msearch1 from c_county size 24,20 ;
        FONT "MS Sans Serif", 8 ;
        STYLE "B" defa c_county(1) when refresh()
```

```
endcase
```

```
mcheck=3
```

```
@ 26,76.800 GET mcheck ;
    PICTURE "@*HT \?\<Quit" ;
    SIZE 1.769,8.667,1.333 ;
    DEFAULT 3 ;
    FONT "MS Sans Serif", 8 ;
    STYLE "B"
```

```
READ CYCLE
```

```
IF NOT WVISIBLE("lm_dmgh")
    ACTIVATE WINDOW lm_dmgh
ENDIF
```

```
if mcheck=1
    exit
endif
```

```
enddo
```

```

RELEASE WINDOW lm_dmgh,lm_brow

return

function refresh

    @17,76 say '-----'
    -----'
    do case
    case menquiry="Catchment"
        @7,90 say msearch
        sele 4
        loca for postcode=msearch
        @9,76 say "Population: "
        @10.5,76 say "Avg Income: "
        @12,76 say "% Econ Act Women: "
        @13.5,76 say "% OAP: "
        @15,76 say "% Carless: "
        @9,96 say popu pict '99999999' style 'B'
        @10.5,96 say income pict '99999999' style 'B'
        @12,96 say actw pict '99999.99' style 'B'
        @13.5,96 say pens pict '99999.99' style 'B'
        @15,96 say Carl pict '99999.99' style 'B'

        npost=substr(msearch,1,6)
        sele 9
        loca for postcode=npost .and. dist<0.1
        mrecl=recn()
        mrec2=mrec1
        mcc=0
        mcust=0
        mmult=0
        mccs=0
        mmults=0
        if .not. eof()

x=0
if x>5

            mcustp=postcode
            sele 1
            seek mcustp
            if .not. eof()
                do while post_code=mcustp
                    mcc=mcc+1
                    mccs=mccs+size__sq_f
                    skip
                enddo
            endif

            sele 13
            seek mcustp
            if .not. eof()
                do while postcode=mcustp
                    mmult=mmult+1
                    mmults=mmults+sales_area
                    skip
                enddo
            endif

            sele 9
            skip

        endif
    endcase
endfunction

```

```

do while .t.
    mcustp=postcode

    sele 11
    seek mcustp
    if .not. eof()
        do while postcode=mcustp
            mcust=mcust+1
            skip
        enddo
    endif

    sele 1
    seek mcustp
    if .not. eof()
        do while post_code=mcustp
            mcc=mcc+1
            mccs=mccs+size__sq_f
            skip
        enddo
    endif

    sele 13
    seek mcustp
    if .not. eof()
        do while postcode=mcustp
            mmult=mmult+1
            mmults=mmults+sales_area
            skip
        enddo
    endif

    sele 9
    skip
    if dist<0.1
        exit
    endif

enddo
mrec2=recn()
endif
@19,96 say 'Num.          Size'
@21,76 say 'Cash & Carry'
@22.5,76 say 'Multiples'
@24,76 say 'Idt Retailer'
@21,96 say mcc pict '9999' style 'B'
@22.5,96 say mmult pict '9999' style 'B'
@24,96 say mcust pict '9999' style 'B'
@21,106 say mccs pict '9999999' style 'B'
@22.5,106 say mmults pict '9999999' style 'B'

brow window lm_brow noedit noappend nodelete nomenu ;
for recn(>=mrec1 .and. recn(<mrec2

case menquiry="County"
    @7,80 say msearch1
    sele 8
    loca for county=msearch1
    @9,76 say "Population: "
    @10.5,76 say "Combined Spending: "
    @12,76 say "% Econ Act Women: "
    @13.5,76 say "% OAP (65+): "
    @15,76 say "% Carless: "
    @9,96 say popu pict '99999999' style 'B'

```

```

@10.5,96 say spend2 pict '999999999' style 'B'
@12,96 say actw/popu*100.00 pict '99999.99' style 'B'
@13.5,96 say pens/popu*100.00 pict '99999.99' style 'B'
@15,96 say h_carl/h_total*100.00 pict '99999.99' style 'B'

```

```

sele 12
loca for upper(county)=msearch1
mrec1=recn()
mrec2=mrec1
mcc=0
mcust=0
mmult=0
mccs=0
mmults=0
if .not. eof()
    skip
    do while .not. eof()
        mcustp=sector

        sele 11
        seek mcustp
        if .not. eof()
            do while postcode=mcustp
                mcust=mcust+1
                skip
            enddo
        endif

        sele 1
        seek mcustp
        if .not. eof()
            do while post_code=mcustp
                mcc=mcc+1
                mccs=mccs+size__sq_f
                skip
            enddo
        endif

        sele 13
        seek mcustp
        if .not. eof()
            do while postcode=mcustp
                mmult=mmult+1
                mmults=mmults+sales_area
                skip
            enddo
        endif

        sele 12
        if upper(county)<>msearch1
            exit
        endif
        skip
    enddo
    mrec2=recn()
endif

@19,96 say 'Num.          Size'
@21,76 say 'Cash & Carry'
@22.5,76 say 'Multiples'
@24,76 say 'Idt Retailer'
@21,96 say mcc pict '9999' style 'B'
@22.5,96 say mmult pict '9999' style 'B'

```

```
@24,96 say mcust pict '9999' style 'B'
@21,106 say mcs pict '9999999' style 'B'
@22.5,106 say mmults pict '9999999' style 'B'

brow window lm_brow noedit noappend nodelete nomenu ;
    for rexn()>=mrec1 .and. rexn()<mrec2

    endcase
@7,76 clear to 25,120
```



```

*          *****
*          *
*          * 28/06/94          LM_SHOW.PRG          14:48:38
*          *
*          *****
*          *
*          * Author's Name
*          *
*          * Copyright (c) 1994 Company Name
*          * Address
*          * City,      Zip
*          *
*          * Description:
*          * This program was automatically generated by GENSCRN.
*          *
*          *****

close database

dimension mbar(150,4),mdepot(150),mpost(150)
sele distinct groupn from land_mb into array c_grp
sele 9
use lm_compl
sele 1
use lm_dept index lm_deptd,lm_deptc,lm_deptp
*set relation to post_code+depot into lm_comp
sele distinct county from lm_dept into array c_county
sele distinct depot+" "+post_code from lm_dept into array c_depot ;
      where member='Y'

*          *****
*          *
*          *          Windows Window definitions
*          *
*          *****
*
on key label f1 help p Depot Comparison

IF NOT WEXIST("lm_show")
  DEFINE WINDOW lm_show ;
    AT 0.000, 0.000 ;
    SIZE 30.923,126.800 ;
    FONT "MS Sans Serif", 8 ;
    title "Depot Characteristics Comparison" ;
    FLOAT ;
    NOCLOSE ;
    MINIMIZE ;
    SYSTEM
ENDIF

*          *****
*          *
*          *          LM_DTQ/Windows Screen Layout
*          *
*          *****
*

#REGION 1
IF WVISIBLE("lm_show")
  ACTIVATE WINDOW lm_show SAME
ELSE
  ACTIVATE WINDOW lm_show NOSHOWN

```

```

ENDIF

msearch1=1
do while .t.

    @ 3.2,76.400 GET menquiry ;
    PICTURE "@^T \<Group;Co\<unt; \<Catchment; \<Aggregate" ;
    SIZE 1.538,18.333 ;
    DEFAULT "Group" ;
    FONT "MS Sans Serif", 8 ;
    STYLE "B"

    @1,0 clear to 26,76
    do case
    case menquiry="Group"
        @5.692,10.400 get msearch from c_grp size 16,38 ;
        FONT "fixedsys",8 ;
        defa c_grp(1) when refresh()

    case menquiry="County"
        @5.692,10.400 get msearch from c_county size 16,38 ;
        FONT "fixedsys",8 ;
        defa c_county(1) when refresh()

    case menquiry="Catchment"
        @5.692,10.400 get msearch from c_depot size 16,38 ;
        FONT "fixedsys",8 ;
        defa c_depot(1) when refresh()

    endcase

    @ 3.292,10.400 to 4.992,71.400 double

    @13,76.8 get mshow1 pict '@*C Turnover' defa 1 style 'b'
    @14,76.8 get mshow2 pict '@*C Depot Size' defa 1 style 'b'
    @15,76.8 get mshow3 pict '@*C Depot Rank' defa 1 style 'b'
    @16,76.8 get mshow4 pict '@*C Price Comp' defa 1 style 'b'

    mcheck=3
    @ 19.615,76.800 GET mcheck ;
    PICTURE "@*HT \!\<OK;\?\<Quit" ;
    SIZE 1.769,8.667,1.333 ;
    DEFAULT 3 ;
    FONT "MS Sans Serif", 8 ;
    STYLE "B"

    READ CYCLE

    IF NOT WVISIBLE("lm_show")
        ACTIVATE WINDOW lm_show
    ENDIF

    do case
    case mcheck=2
        exit
    case mcheck>2
        loop
    endcase

    do case
    case menquiry="Group"
        sele 1
        set order to 1

```

```

go top
i=0
do while .not. eof()
    if groupn=msearch
        i=i+1
        mbar(i,1)=turnoverxx
        mbar(i,2)=size__sq_f
        mbar(i,3)=depot_rank
        mbar(i,4)=price_comp
        mdepot(i)=depot
        mpost(i)=post_code
    endif
    skip
enddo
mtitle='in Group '+trim(msearch)

case menquiry="County"
    sele 1
    set order to 2
    seek msearch
    i=0
    if .not. eof()
        do while county=msearch
            i=i+1
            mbar(i,1)=turnoverxx
            mbar(i,2)=size__sq_f
            mbar(i,3)=depot_rank
            mbar(i,4)=price_comp
            mdepot(i)=depot
            mpost(i)=post_code
            skip
        enddo
    endif
    mtitle=' in County '+trim(msearch)
case menquiry='Catchment'
    md=substr(msearch,1,25)
    mp=substr(msearch,28,8)
    i=0
    sele 1
    set order to 3
    loca for depot=md .and. post_code=mp
    if .not. eof()
        i=1
        mbar(i,1)=turnoverxx
        mbar(i,2)=size__sq_f
        mbar(i,3)=depot_rank
        mbar(i,4)=price_comp
        mdepot(i)=depot
        mpost(i)=post_code
        mmrec=recn()
        mmpost=substr(post_code,1,6)
    endif
    msearch=mp+" "+md
    sele 9
    locate for postcode=mmpost and dist=0
    if .not. eof()
        skip
        do while dist>0
            if dist<999.9
                mmpost=postcode
                mdist=dist
                sele 1
                seek mmpost
            endif
        enddo
    endif
enddo

```

```

        if .not. eof()
            do while post_code=trim(mmpost)
                if recn() <> mmrec
                    i=i+1
                    mbar(i,1)=turnoverxx
                    mbar(i,2)=size__SQ_F
                    mbar(i,3)=depot_rank
                    mbar(i,4)=price_comp
                    mdepot(i)=depot
                    mpost(i)=post_code
                endif
            skip
            enddo
        endif

        sele 9
        endif
        skip
    enddo
endif
mtitle='in Catchment Area of '+trim(msearch)
case menquiry='Aggregate'
    store 0 to msum1,msum2,msum3,msum4,mctn
    sele 1
    i=alen(c_grp)
    for j=1 to i
        mgroup=c_grp(j)
        calculate
sum(turnoverxx),sum(size__sq_f),sum(depot_rank),;
        sum(price_comp),cnt() ;
        for groupn=mgroup to msum1,msum2,msum3,msum4,mctn
            if mctn>0
                mavg1=msum1/mctn
                mavg2=msum2/mctn
                mavg3=msum3/mctn
                mavg4=msum4/mctn
            endif
            mbar(j,1)=mavg1
            mbar(j,2)=mavg2
            mbar(j,3)=mavg3
            mbar(j,4)=mavg4
            mdepot(j)=mgroup
            mpost(j)=''
        endfor
        mtitle='for Groups'
    endcase

    if i>0
        do lm_bar with
mbar,mdepot,mpost,i,mtitle,mshow1,mshow2,mshow3,mshow4
    endif

    clear

enddo

RELEASE WINDOW lm_show

return

function refresh

```

```
@3.692,11.400 say space(30)
@ 3.692,11.400 say msearch pict "@" ;
      FONT "fixedsys",8
```

```

*          *****
*          *
*          * 30/03/95          LM_MULTQ.PRG          14:48:38
*          *
*          *****
*          *
*          * Author's Name
*          *
*          * Copyright (c) 1994 Company Name
*          * Address
*          * City,      Zip
*          *
*          * Description:
*          * Enquiry for the multiples
*          *
*          *****

```

```

sp=space(30)
close database

```

```

sele 9
use lm_mult
sele distinct trade_name from lm_mult into array c_name
*sele distinct postcode from lm_mult into array c_post
sele distinct add_town from lm_mult into array c_town

```

```

*set topic to 'p Multiple Information'
on key label fl help p Multiple Information

```

```

*          *****
*          *
*          *          Windows Window definitions
*          *
*          *
*          *****
*

```

```

IF NOT WEXIST("lm_multq")
    DEFINE WINDOW lm_multq ;
        AT 0.000, 0.000 ;
        SIZE 30.923,126.800 ;
        FONT "MS Sans Serif", 8 ;
        title "Multiples Enquiry" ;
        FLOAT ;
        NOCLOSE ;
        MINIMIZE ;
        SYSTEM
ENDIF

```

```

IF WVISIBLE("lm_multq")
    ACTIVATE WINDOW lm_multq SAME
ELSE
    ACTIVATE WINDOW lm_multq NOSHOW
ENDIF

```

```

msearch1=1
msearch=space(40)
nsearch=''
do while .t.

```

```

@ 3.692,76.400 GET menquiry ;
    PICTURE "@^T \<Name;T\<own;\<Telephone;C\<haracteristics" ;
    SIZE 1.538,18.333 ;
    DEFAULT "Name" ;

```

```

        FONT "MS Sans Serif", 8 ;
        STYLE "B"

*@1,0 clear to 26,70
do case
case menquiry="Name"

    @5,16 get msearch from c_name size 16,26 ;
    FONT "MS Sans Serif", 8 ;
    STYLE "B" defa c_name(1) valid refresh()

case menquiry="Town"

    @3,44 clear to 26,70
    @5,16 get msearch from c_town size 16,26 ;
    FONT "MS Sans Serif", 8 ;
    STYLE "B" defa c_town(1) when refresh2()

case menquiry="Telephone"

    @1,0 clear to 26,70
    @5,16 say "Please input trader's telephone"
    @6,16 get msearch pict '@!'

case menquiry='Characteristics'
    @1,0 clear to 26,70
    @ 5.692,26.400 GET msearch1 ;
    PICTURE "@*RVT \<Gross area;\<Sales area;\<Car park
area;"++;
    "C\<checkouts" ;
    SIZE 1.308,25.000,0.308 ;
    FONT "MS Sans Serif", 8 ;
    STYLE "BT"
    @14,26.4 say 'Please choose the search range' ;
    FONT "MS Sans Serif", 8 STYLE "BT"

    @16,26.4 say 'Upper level: ' ;
    FONT "MS Sans Serif", 8 STYLE "BT"
    @18,26.4 say 'Lower level: ' ;
    FONT "MS Sans Serif", 8 STYLE "BT"
do case
case msearch1=1
    mmax=30000
    mmin=mmax
    @ 16,44 GET mmax ;
    SPINNER 200, 0, 999999 ;
    PICTURE "@K" ;
    SIZE 0.846, 8.400 ;
    FONT "MS Sans Serif", 8
    @ 18,44 GET mmin ;
    SPINNER 200, 0, 999999 ;
    PICTURE "@K" ;
    SIZE 0.846, 8.400 ;
    FONT "MS Sans Serif", 8
case msearch1=2
    mmax=30000
    mmin=mmax
    @ 16,44 GET mmax ;
    SPINNER 200, 0, 999999 ;
    PICTURE "@K" ;
    SIZE 0.846, 8.400 ;
    FONT "MS Sans Serif", 8
    @ 18,44 GET mmin ;

```

```

        SPINNER 200, 0, 999999 ;
        PICTURE "@K" ;
        SIZE 0.846, 8.400 ;
        FONT "MS Sans Serif", 8
    case msearch1=3
        mmax=300
        mmin=mmax
        @ 16,44 GET mmax ;
        SPINNER 20, 0, 999999 ;
        PICTURE "@K" ;
        SIZE 0.846, 8.400 ;
        FONT "MS Sans Serif", 8
        @ 18,44 GET mmin ;
        SPINNER 20, 0, 999999 ;
        PICTURE "@K" ;
        SIZE 0.846, 8.400 ;
        FONT "MS Sans Serif", 8
    case msearch1=4
        mmax=30
        mmin=mmax
        @ 16,44 GET mmax ;
        SPINNER 1, 0, 999 ;
        PICTURE "@K" ;
        SIZE 0.846, 8.400 ;
        FONT "MS Sans Serif", 8
        @ 18,44 GET mmin ;
        SPINNER 1, 0, 999 ;
        PICTURE "@K" ;
        SIZE 0.846, 8.400 ;
        FONT "MS Sans Serif", 8
    endcase

endcase

if menquiry='Name' or menquiry='Town'
    @ 3,16 to 4.9,48 double
    @ 3.5,17 GET msearch ;
    SIZE 1,24 FONT "MS Sans Serif", 8 STYLE "BT"
endif

mcheck=3

@ 19.615,76.800 GET mcheck ;
    PICTURE "@*HT \\!<OK;\\?<Quit" ;
    SIZE 1.769,8.667,1.333 ;
    DEFAULT 3 ;
    FONT "MS Sans Serif", 8 ;
    STYLE "B"

READ CYCLE

IF NOT WVISIBLE("lm_multq")
    ACTIVATE WINDOW lm_multq
ENDIF

do case
case mcheck=2
    exit
case mcheck>2
    loop
endcase

do case

```



```

case menquiry="Name"
  mdd=upper(alltrim(msearch))
  mddl=upper(alltrim(nsearch))
  if len(mddl)>0
    mcond="mdd$upper(trade_name) .and. mddl$upper(postcode)"
  else
    mcond="mdd$upper(trade_name)"
  endif
  mmes="Trader Name : &mdd and postcode : &mdd"
  do display

case menquiry="Town"
  mdd=upper(alltrim(msearch))
  mcond="mdd$upper(add_town)"
  mmes="Trader's Town by Keyword:   &mdd"
  do display

case menquiry="Telephone"
  mdd=alltrim(msearch)
  mcond="mdd$phone"
  mmes="Trader Telephone by Keyword:   &mdd"
  do display

case menquiry="Characteristics"
  do case
  case msearch1=1
    mcond="gross_area>=mmin .and. gross_area<=mmax"
    nmin=str(mmin,6,1)
    nmax=str(mmax,6,1)
    mmes="Gross area between  &nmin  and  &nmax"
  case msearch1=2
    mcond="Sales_area>=mmin .and. sales_area<=mmax"
    nmin=str(mmin,8)
    nmax=str(mmax,8)
    mmes='Sales area between  &nmin  and  &nmax'
  case msearch1=3
    mcond="car_park>=mmin .and. car_park<=mmax"
    nmin=str(mmin,8)
    nmax=str(mmax,8)
    mmes='Car park area between  &nmin  and  &nmax'
  case msearch1=4
    mcond="chk_outs>=mmin .and. chk_outs<=mmax"
    nmin=str(mmin,8)
    nmax=str(mmax,8)
    mmes='Check out numbers between  &nmin  and  &nmax'
  endcase
  do display

endcase
clear

enddo

RELEASE WINDOW lm_multq

*return

procedure display

clear
*      *****
*      *
*      *      Windows Window definitions

```

```

*          *
*          *****
*
*set topic to 'b Detailed Multiple Info'
on key label f1 help Detailed Multiple Info

IF NOT WEXIST("Trader_query")
    DEFINE WINDOW Trader_query ;
        AT 0.000, 0.000 ;
        SIZE 31.538,126.800 ;
        title "Detailed Trader Information" ;
        FONT "MS Sans Serif", 8 ;
        FLOAT ;
        NOCLOSE ;
        MINIMIZE ;
        SYSTEM
ENDIF

IF WVISIBLE("Trader_query")
    ACTIVATE WINDOW Trader_query SAME
ELSE
    ACTIVATE WINDOW Trader_query NOSHOW
ENDIF
mc=", "
mp=space(30)
maddress=address1

locate for &mcond
if .not. eof()

do while .t.
    clear

    if &mcond
        maddress1=address1
        if address2=mp
            maddress2=''
        else
            maddress1=maddress1+mc+address2+mc
            if address3=mp
                maddress2=''
            else
                maddress2=address3
                if address4<>mp
                    maddress2=maddress2+mc+address4
                endif
            endif
        endif
    endif

    @ 2,0 SAY "Trader Name" ;
        FONT "MS Sans Serif", 8 ;
        STYLE "BT"
    @ 2,20 say trade_name
    @ 2,50 SAY "Post code" ;
        FONT "MS Sans Serif", 8 ;
        STYLE "BT"
    @ 2,70 say postcode
    @ 3,0 say "Address" ;
        FONT "MS Sans Serif", 8 ;
        STYLE "BT"
    @ 3,20 say maddress1
    @ 4,20 say maddress2

```

```

@ 5,0 say "Telephone" ;
    FONT "MS Sans Serif", 8 ;
    STYLE "BT"
@ 5,20 say phone

@ 8,0 say '-----'+;
    ' Characteristics -----' ;

    FONT "MS Sans Serif", 8 ;
    STYLE "BT"
@ 10,10 say "Gross area" FONT "MS Sans Serif", 8 STYLE
"BT"
if gross_area>0
    @ 10,30 say gross_area pict "999999999"
endif
@ 11,10 say "Sales area" FONT "MS Sans Serif", 8 STYLE
"BT"
if sales_area>0
    @ 11,30 say sales_area pict "999999999"
endif
@ 10,50 say "Car park area" FONT "MS Sans Serif", 8 STYLE
"BT"
if car_park>0
    @ 10,70 say car_park pict "999999999"
endif
@ 11,50 say "Checkout number" FONT "MS Sans Serif", 8
STYLE "BT"
if chk_outs>0
    @ 11,70 say chk_outs pict "999999999"
endif
@12,10 say "Scanning status" FONT "MS Sans Serif", 8 STYLE
"BT"
@12,34 say scan_flag
@12,50 say "Licensed status" FONT "MS Sans Serif", 8 STYLE
"BT"
@12,74 say alc_flag
@13,10 say "Petrol station" FONT "MS Sans Serif", 8 STYLE
"BT"
@13,34 say petro_flag
@13,50 say "Sunday openning" FONT "MS Sans Serif", 8 STYLE
"BT"
@13,74 say sun_flag
mrec=recn()
do while .not. eof()
    skip
    if &mcond
        exit
    endif
enddo
if eof()
    mnext='\\'
else
    mnext=''
endif
go mrec
do while .not. bof()
    skip -1
    if &mcond
        exit
    endif
enddo
if bof()
    mprev='\\'

```

```

else
    mprev=''
endif
go mrec

@ 10.000,106.000 GET m.choice ;
    PICTURE "@*VT
"+mnext+"!\<Next;"+mprev+"!\<Previous;?\<Exit" ;
    SIZE 1.769,10.333,0.308 ;
    DEFAULT 1 ;
    FONT "MS Sans Serif", 8 ;
    STYLE "B"

IF NOT WVISIBLE("Trader_query")
    ACTIVATE WINDOW Trader_query
ENDIF

READ CYCLE

do case
case m.choice=1
    do while .not. eof()
        skip
        if &mcond
            exit
        endif
    enddo
case m.choice=2
    do while .not. bof()
        skip -1
        if &mcond
            exit
        endif
    enddo
case m.choice>=3
    exit
endcase
endif
enddo

endif
clear

release windows Trader_query

return

function refresh
    @3.5,17 say space(42)
    @ 3.5,17 say msearch SIZE 1,24 FONT "MS Sans Serif", 8 STYLE
"BT"
    sele distinct postcode from lm_mult into array c_post ;
        where trade_name=msearch or trade_name=' '
    @5,50 get nsearch from c_post size 16,14 ;
        FONT "MS Sans Serif", 8 ;
        STYLE "B" defa c_post(1) when refresh1()
    @19,76 clear to 22,110
    @ 19.615,80 GET mcheck1 PICTURE "@*HT \!\<Back" ;
        SIZE 1.769,8.667,1.333 DEFAULT 1 FONT "MS Sans Serif", 8
STYLE "B"
    @ 3,50 to 4.9,67 double
    @ 3.5,51 GET nsearch ;
        SIZE 1,12 FONT "MS Sans Serif", 8 STYLE "BT"

```

```
    read cycle
    clear read
    @19,76 clear to 22,110

function refresh1
    @3.5,51 say space(20)
    @ 3.5,51 say nsearch SIZE 1,12 FONT "MS Sans Serif", 8 STYLE
"BT"

function refresh2
    @3.5,17 say space(42)
    @ 3.5,17 say msearch SIZE 1,24 FONT "MS Sans Serif", 8 STYLE
"BT"
```

```

*          *****
*          *
*          * 23/01/95                LM_FOODQ.PRG                14:48:38
*          *
*          *****
*          *
*          * Author's Name
*          *
*          * Copyright (c) 1994 Company Name
*          * Address
*          * City,      Zip
*          *
*          * Description:
*          * Enquiry for the food/grocery traders
*          *
*          *****

```

```

sp=space(30)
close database

```

```

sele 9
use lm_food

```

```

*set topic to 'p Depot Information'
on key label fl help p Depot Information

```

```

*          *****
*          *
*          *          Windows Window definitions
*          *
*          *****
*

```

```

IF NOT WEXIST("lm_foodq")
    DEFINE WINDOW lm_foodq ;
        AT 0.000, 0.000 ;
        SIZE 30.923,126.800 ;
        FONT "MS Sans Serif", 8 ;
        title "Food/Grocery Trader Enquiry" ;
        FLOAT ;
        NOCLOSE ;
        MINIMIZE ;
        SYSTEM
ENDIF

```

```

*          *****
*          *
*          *          LM_Foodq/Windows Screen Layout
*          *
*          *****
*

```

```

#REGION 1
IF WVISIBLE("lm_foodq")
    ACTIVATE WINDOW lm_foodq SAME
ELSE
    ACTIVATE WINDOW lm_foodq NOSHOW
ENDIF

```

```

msearch1=1
msearch=space(40)
do while .t.

```

```

@ 3.692,76.400 GET menquiry ;
    PICTURE "@^T \<Name;\<Address;\<Telephone;\<Characteristics" ;
    SIZE 1.538,18.333 ;
    DEFAULT "Name" ;
    FONT "MS Sans Serif", 8 ;
    STYLE "B"

@1,0 clear to 26,70
do case
case menquiry="Name"

    @5,16 say "Please input the trader's name"
    @6,16 get msearch pict '@!'

case menquiry="Address"

    @5,16 say "Please input the trader's address"
    @6,16 get msearch pict '@!'

case menquiry="Telephone"

    @5,16 say "Please input the trader's telephone"
    @6,16 get msearch pict '@!'

case menquiry='Characteristics'
    @ 5.692,26.400 GET msearch1 ;
        PICTURE "@*RVT Turnover;Employees" ;
        SIZE 1.308,25.000,0.308 ;
        FONT "MS Sans Serif", 8 ;
        STYLE "BT"
    @14,26.4 say 'Please choose the search range' ;
        FONT "MS Sans Serif", 8 STYLE "BT"

    @16,26.4 say 'Upper level: ' ;
        FONT "MS Sans Serif", 8 STYLE "BT"
    @18,26.4 say 'Lower level: ' ;
        FONT "MS Sans Serif", 8 STYLE "BT"
do case
case msearch1=1
    mmax=50000000
    mmin=mmax
    @ 16,44 GET mmax ;
    SPINNER 100000, 0, 999999999 ;
    PICTURE "@K" ;
    SIZE 0.846, 10.400 ;
    DEFAULT 5000000 ;
    FONT "MS Sans Serif", 8
    @ 18,44 GET mmin ;
    SPINNER 100000, 0, 999999999 ;
    PICTURE "@K" ;
    SIZE 0.846, 10.400 ;
    DEFAULT 5000000 ;
    FONT "MS Sans Serif", 8
case msearch1=2
    mmax=1000
    mmin=mmax
    @ 16,44 GET mmax ;
    SPINNER 100, 0, 999999 ;
    PICTURE "@K" ;
    SIZE 0.846, 8.400 ;
    FONT "MS Sans Serif", 8
    @ 18,44 GET mmin ;

```

```

                SPINNER 100, 0, 999999 ;
                PICTURE "@K" ;
                SIZE 0.846, 8.400 ;
                FONT "MS Sans Serif", 8
            endcase

        endcase

        mcheck=3

        @ 19.615,76.800 GET mcheck ;
            PICTURE "@*HT \!\<OK;\?\<Quit" ;
            SIZE 1.769,8.667,1.333 ;
            DEFAULT 3 ;
            FONT "MS Sans Serif", 8 ;
            STYLE "B"

        READ CYCLE

        IF NOT WVISIBLE("lm_foodq")
            ACTIVATE WINDOW lm_foodq
        ENDIF

        do case
        case mcheck=2
            exit
        case mcheck>2
            loop
        endcase

        do case
        case menquiry="Name"
            mdd=alltrim(msearch)
            mcond="mdd$name"
            mmes="Trader Name by Keyword: &mdd"
            do display

        case menquiry="Address"
            mdd=alltrim(msearch)
            mcond="mdd$address1+address2+address3+address4"
            mmes="Trader Address by Keyword: &mdd"
            do display

        case menquiry="Telephone"
            mdd=alltrim(msearch)
            mcond="mdd$phone"
            mmes="Trader Telephone by Keyword: &mdd"
            do display

        case menquiry="Characteristics"
            do case
            case msearch1=1
                mcond="turn>=mmin .and. turn<=mmax"
                nmin=str(mmin,6,1)
                nmax=str(mmax,6,1)
                mmes="Turnover Between &nmin and &nmax"
            case msearch1=2
                mcond="employee>=mmin .and. employee<=mmax"
                nmin=str(mmin,8)
                nmax=str(mmax,8)
                mmes='Depot Size Between &nmin and &nmax'
            endcase
            do display

```



```

endcase
clear

enddo

RELEASE WINDOW lm_foodq

*return

procedure display

clear
*
* *****
*
*
*           Windows Window definitions
*
* *****
*

*set topic to 'Detailed Depot Information'
on key label f1 help Detailed Depot Information

IF NOT WEXIST("Trader_query")
    DEFINE WINDOW Trader_query ;
        AT 0.000, 0.000 ;
        SIZE 31.538,126.800 ;
        title "Detailed Trader Information" ;
        FONT "MS Sans Serif", 8 ;
        FLOAT ;
        NOCLOSE ;
        MINIMIZE ;
        SYSTEM
ENDIF

IF WVISIBLE("Trader_query")
    ACTIVATE WINDOW Trader_query SAME
ELSE
    ACTIVATE WINDOW Trader_query NOSHOW
ENDIF
mc=", "
mp=space(30)
maddress=address1

locate for &mcond
if .not. eof()

do while .t.
    clear

    if &mcond
        maddress1=address1
        if address2=mp
            maddress2=''
        else
            maddress1=maddress1+mc+address2+mc
            if address3=mp
                maddress2=''
            else
                maddress2=address3
                if address4<>mp
                    maddress2=maddress2+mc+address4
                endif
            endif
        endif
    endif

```

```

endif
endif

if trade2=mp
    mtrade=trade
else
    mtrade=trim(trade)+mc+trade2
endif

@ 2,0 SAY "Trader Name" ;
    FONT "MS Sans Serif", 8 ;
    STYLE "BT"
@ 2,20 say name
@ 3,0 say "Address" ;
    FONT "MS Sans Serif", 8 ;
    STYLE "BT"
@ 3,20 say maddress1
@ 4,20 say maddress2
@ 5,0 say "Telephone" ;
    FONT "MS Sans Serif", 8 ;
    STYLE "BT"
@ 5,20 say phone
@ 5,50 say "Director" ;
    FONT "MS Sans Serif", 8 ;
    STYLE "BT"
@ 5,70 say director
@ 6,0 say "Activities" ;
    FONT "MS Sans Serif", 8 ;
    STYLE "BT"
@ 6,20 say mtrade

@ 8,0 say '-----'+;
    ' Characteristics -----'
-----' ;

    FONT "MS Sans Serif", 8 ;
    STYLE "BT"
@ 10,10 say "Turnover" ;
    FONT "MS Sans Serif", 8 ;
    STYLE "BT"
if turn>0
    @ 10,30 say turn pict "999999999"
endif
@ 10,50 say "Turnover in UK" ;
    FONT "MS Sans Serif", 8 ;
    STYLE "BT"
if turn_uk>0
    @ 10,70 say turn_uk pict "999999999"
endif
@ 11,10 say "Employees" ;
    FONT "MS Sans Serif", 8 ;
    STYLE "BT"
if employee>0
    @ 11,30 say employee pict "999999999"
endif
@ 11,50 say "Fix Assests" ;
    FONT "MS Sans Serif", 8 ;
    STYLE "BT"
if fass>0
    @ 11,70 say fass pict "999999999"
endif
mrec=recln()
do while .not. eof()

```

```

        skip
        if &mcond
            exit
        endif
    enddo
    if eof()
        mnext='\'
    else
        mnext=''
    endif
    go mrec
    do while .not. bof()
        skip -1
        if &mcond
            exit
        endif
    enddo
    if bof()
        mprev='\'
    else
        mprev=''
    endif
    go mrec

    @ 10.000,106.000 GET m.choice ;
    PICTURE "@*VT
"+mnext+"!\<Next;" +mprev+" \<Previous;\? \<Quit" ;
    SIZE 1.769,10.333,0.308 ;
    DEFAULT 1 ;
    FONT "MS Sans Serif", 8 ;
    STYLE "B"

    IF NOT WVISIBLE("Trader_query")
        ACTIVATE WINDOW Trader_query
    ENDIF

    READ CYCLE

    do case
    case m.choice=1
        do while .not. eof()
            skip
            if &mcond
                exit
            endif
        enddo
    case m.choice=2
        do while .not. bof()
            skip -1
            if &mcond
                exit
            endif
        enddo
    case m.choice>=3
        exit
    endcase
endif
enddo

endif
clear

release windows Trader_query

```

return

```

*          *****
*          *
*          * 15/06/94          LM_PRINT.PRG          14:47:35
*          *
*          *****
*          *
*          * Author's Name
*          *
*          * Copyright (c) 1994 Company Name
*          * Address
*          * City,      Zip
*          *
*          * Description:
*          * This program was automatically generated by GENSCRN.
*          *
*          *****

```

```

mpicture='@^N Detailed Depot Information by COUNTY;'+;
'Detailed Depot Information by GROUP;'+;
'Aggregate Depot Information'
*=adir(c_file,"lmsdss\*.txt")
mpath='lmsdss\'

```

on key label f1 help p Print...

```

*          *****
*          *
*          *          Windows Window definitions
*          *
*          *****
*

```

```

IF NOT WEXIST("lm_print")
  DEFINE WINDOW lm_print ;
    AT 0.000, 0.000 ;
    SIZE 30.900,126.800 ;
    FONT "MS Sans Serif", 8 ;
    title "Print out File Selection" ;
    FLOAT ;
    NOCLOSE ;
    MINIMIZE ;
    SYSTEM
ENDIF

```

```

*          *****
*          *
*          *          AA/Windows Screen Layout
*          *
*          *****
*

```

```

IF WVISIBLE("lm_print")
  ACTIVATE WINDOW lm_print SAME
ELSE
  ACTIVATE WINDOW lm_print NOSHOW
ENDIF

```

```

mfile='lm_print.TXT'
do while .t.

  @3.292,16.400 get nprint ;
  PICTURE mpicture ;

```

```

        SIZE 1.538,42 ;
        DEFAULT 'Detailed Depot Information by COUNTY' ;
        FONT "MS Sans Serif", 8 ;
        STYLE "B"

@1,78 clear to 20,120
@ 3.692,78.400 GET moutput ;
    PICTURE "@*RVT To Screen;To Print" ;
    default 1 ;
    SIZE 1.308,25.000,0.308 ;
    FONT "MS Sans Serif", 8 ;
    STYLE "BT"

if moutput=3

    @11.092,78.400 get mfile from c_file size 8,18 ;
    FONT "MS Sans Serif", 8 ;
    STYLE "B" defa c_file(1) when refresh1()

    @9.292,78.400 to 10.992,100.400 double
    @9.692,79.400 GET mfile ;
    SIZE 1,15 pict "@!" ;
    default "*.txt" ;
    FONT "MS Sans Serif", 8 ;
    STYLE "BT"

endif

mcheck=0
@ 20.015,78.400 GET mcheck ;
    PICTURE "@*HT \!\<OK;\?\<Quit" ;
    SIZE 1.769,8.667,1.333 ;
    DEFAULT 3 ;
    FONT "MS Sans Serif", 8 ;
    STYLE "B"

READ CYCLE

do case
case mcheck=0
    loop
case mcheck=2
    exit
endcase

mfile=mpath+mfile

do case
case nprint="Detailed Depot Information by COUNTY"
    do lm_dtp1 with moutput,mfile
case nprint='Detailed Depot Information by GROUP'
    do lm_dtp3 with moutput,mfile
case nprint='Aggregate Depot Information'
    do lm_dtp2 with moutput,mfile
endcase
clear
enddo

RELEASE WINDOW lm_print

return

function refresh1

```

```
@9.692,79.400 say space(30)
@9.692,79.400 say mfile ;
      SIZE 1,15 pict "@" ;
      FONT "MS Sans Serif", 8 ;
      STYLE "BT"
```